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MONTHLY WEATHER REVIEW

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ON FORECASTING THE DIRECTION OF MOVEMENT OF WINTER CYCLONES

WAYNE C. PALMER

[U. S. Weather Bureau, Washington, D. C.]

Manuscript received June 18, 1948

INTRODUCTION

THE PROBLEM

A need has long existed for a more systematic technique for quickly forecasting the location and intensity of cyclones. This need has been felt particularly at the Weather Bureau–Air Force–Navy Analysis Center, where prognostic pressure charts for wide areas must be prepared regularly, with a minimum time interval between collection of the data and dissemination of the finished charts.

Although it is well recognized that the direction of movement, the speed of movement, and the deepening and filling of cyclones are so interrelated as to constitute a single problem, the direction of movement during a 30-hour period was selected as the subject of the first investigation.[1] This selection was made because it seemed advisable to attack the various aspects of the problem individually in order to reduce the investigation to a reasonable scale, and the direction of movement seemed to be the simplest aspect and at the same time one of the most vital. A forecast of direction of cyclone movement during the next 30 hours is defined as the straight line extending from the current map position of an existing surface cyclone to the point at which the cyclone will be located 30 hours later—the line on which it will be found 30 hours later, regardless of the path it may follow or the distance it may travel during the period.

LIMITATIONS OF THE PRESENT STUDY

In order to secure data with some degree of homogeneity, the investigation was confined to cyclones found in the region of the United States and Canada east of the Continental Divide. Restrictions in season also seemed advisable, and therefore, only the winter months of December, January, and February were considered.

With attention to the operational problems of the WBAN Analysis Center, it was obvious that, to be useful, any technique developed must employ only those data which are available to the forecaster at the time he is preparing the prognostic chart; also, the technique must be sufficiently simple that a disproportionate amount of time will not be consumed in using it.

[1] A study designed to forecast the 30-hour deepening and filling of winter cyclones is in manuscript form and will be published later, and work is currently being done on the problem of forecasting the 30-hour speed of movement of winter cyclones.

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METHODS OF INVESTIGATION

A study such as this can be considered to comprise four distinct phases: first, selection of important factors related to the specific problem, based on previous theoretical studies and the experience of forecasters; second, measurement and numerical expression of those factors; third, determination from past data of their combined relationship to the item to be forecast; and fourth, verification of prognostications made by applying the developed technique to independent data. The second phase is the most difficult, although the value of the study depends on the outcome of the independent tests.

This investigation was not intended to discover new variables to be used in forecasting but, rather, to evaluate systematically some of the more important ones which are currently used or advocated. When a forecaster is deciding something about where a given low pressure center will be at some future time, he considers many aspects of current and past synoptic charts such as past movement, field of 3-hour isallobars, field of 12-hour pressure changes at sea level, general appearance of the current sea level pressure chart, flow patterns and changes at various upper levels, three-dimensional temperature field, and many others. In order to find the degree to which such aspects of the current meteorological situation are indicative of the subsequent 30-hour direction of movement of the low pressure center, a simple graphical procedure was employed in this study. A meteorological factor capable of numerical expression from available data was evaluated for a number of cases and then plotted against the ordinate of observed direction of movement of the low center during the following 30 hours. (Fig. 10 illustrates this procedure.) This method of investigation makes possible the establishment of relationships between the variable and the item to be forecast, without the necessity of first knowing the exact form of the relationship. If the data, when plotted on the graph, are found to be arranged in a systematic fashion, such as along and about a straight line or a curve, a relationship can be said to exist; if they are not arranged along some simple or slightly complex curve, it can only be concluded that any existing relationship is not evident from this simple method of handling the data. The variable under consideration must then be discarded, or some more precise means of expressing it must be found.

If it is suspected that two variables operate in a fashion demanding that they should be considered simultaneously, one can be used as the ordinate of a graph with the other as the abscissa, and the observed value of the item to be forecast (in this study, the observed direction of movement of the low center) can be entered at the intersection thus determined. (Fig. 14 illustrates this procedure.) When this type of graph includes a large number of cases, the values entered at the intersections can be analyzed for distribution and gradient; if some relationship exists, isopleths can be drawn. This simple device can be used advantageously on many problems when the exact forms of relationships are not known. To some extent, it takes care of the difficulty which frequently confronts a forecaster when consideration of two separate variables suggests differing forecasts. Sometimes the indications from one variable will be more nearly correct, sometimes the indications from the other. If the data are handled properly, this graphical technique will tend to give the proper weight to the various factors and thus help in resolving the forecaster's problem by indicating when one factor is more important than another.

The very simplicity of this approach may make it appear to the reader that a study such as this one is arbitrary, empirical, and superficial, This impression may be the result of the simple measures which are frequently used to express some aspect of a meteorological situation. For example, in a particular study it may be found, after rather exhaustive tests, that the surface dew point at some station is almost as good a measure of the amount of moisture in the air as more elaborate evaluations, such as total precipitable water in the atmospheric column or mean moisture content in some particular isentropic layer; then it is quite natural that the dew point will be used because it is so readily obtained. To the cursory reader the dew point at this particular station may seem to be of only minor importance in the solution of the problem at hand; but its use may be justified when closer examination shows that extreme values of dew point at that station will occur only with a certain synoptic situation, and that the dew point value is therefore a far more significant indicator than was first believed. Also, although it has often been found that more elaborate measures give somewhat better results, they may not be enough better to justify the additional difficulty and time involved in obtaining and resolving them into a unified forecasting tool.

INVESTIGATIONS

Of the 25 or 30 different factors which were investigated in the course of this study, 4 which seemed to contain nearly all of the useful information readily available from the current synoptic charts were:

1. A normal 24-hour direction of movement based on the data published by Bowie and Weightman [1].
2. The direction the particular cyclone moved during the past 6 hours.
3. The orientation of the major trough in the sea-level pressure pattern.
4. The direction from the 3-hour anallobaric center behind the cyclone to the 3-hour katallobaric center ahead of the cyclone.

A discussion of some of the other factors investigated will be found in the APPENDIX to this paper.

NORMAL DIRECTION OF MOVEMENT

When an experienced forecaster looks at a given weather situation and remarks that such a low generally moves "so and so," he is drawing upon the total of his experience with lows similar to the one in question. In a subjective way he has formed in his mind a "normal" path for such lows. There seems little doubt that this information is useful in forecasting; therefore, a quantitative evaluation of "normal" direction should be even more useful.

The work of Bowie and Weightman [1] gives, for each map area 5° square, the average 24-hour speed and direction of movement of lows for each month of the year. (No 30-hour averages were available.) These averages are based on 20 years of data and are grouped according to the geographical area (see fig. 1) in which the low first appeared and from which it received its type designation. Examination of the Bowie and Weightman data disclosed that the averages for some 5° squares were based on very few cases. For the purpose of the present study a more stable "normal" direction was needed. Inasmuch as the changes of the Bowie and Weightman average directions from month to month at any geographical point were considerably less than the changes of the averages from point to point, it was decided that representative "winter" normal directions by geographical type could be obtained by combining Bowie and Weightman data for the months of December, January, and February. This was done, with each month being weighted according to the number of cases of a particular type of cyclone recorded in the original observations for that month.

Figures 2 through 9 show the results of combining these winter data; the geographical types of the earlier investigation have been maintained separately, except for the South Atlantic and East Gulf types which were combined into a single normal chart because few data were available for either and differences between the types did not appear to be great. The average observed 24-hour direction of movement is shown by the numbers appearing on the maps in the center of each 5° square of figures 2 through 9; numbers in parentheses give the total number of "winter" cases which appear in that 5° square on the Bowie and Weightman maps. For example, in figure 4, the 5° square from 35° N. to 40° N. lat., and from 110° W. to 115° W. long., shows a direction of 0° for the average direction of movement of the 33 cases of South Pacific Lows. The 0° for direction of movement means a straight line tangent to the parallel of 37½° N. lat., at 112½° W. long., which in this case, therefore, passes approximately through Tulsa, Okla., and Savannah, Ga. (The error of measurement is negligible for directions laid off in this way on any conformal conic map projection, using an ordinary protractor oriented according to the meridians; however, a special direction-measuring device has to be used on other map projections.) The isograms on these maps were drawn and labeled in terms of degrees from "east" ("east" being 0° laid off as indicated above). Positive values indicate degrees north of east, and negative values show degrees south of east (with north as +90° and south as −90°). For example, an Alberta Low situated at Milwaukee, Wis., has an average 24-hour direction of movement of +15° (see fig. 2), which indicates a line approximately through Bangor, Maine.

In order to determine something of the usefulness of these modified Bowie and Weightman average directions, hereafter referred to as normal directions, 68 cases of winter cyclones east of the Continental Divide were

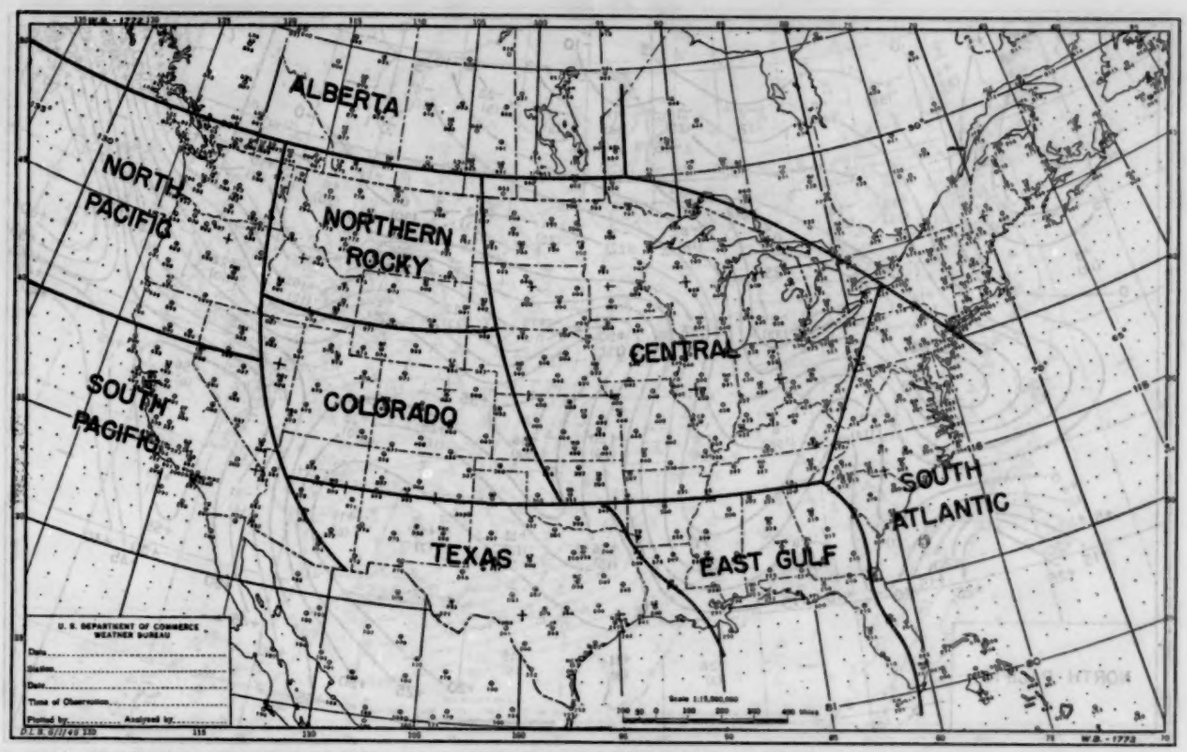

FIGURE 1.—Map showing regions of first appearance of storms on the weather map of the United States and Canada, used for designation of storm types. (From Bowie and Weightman [1]).

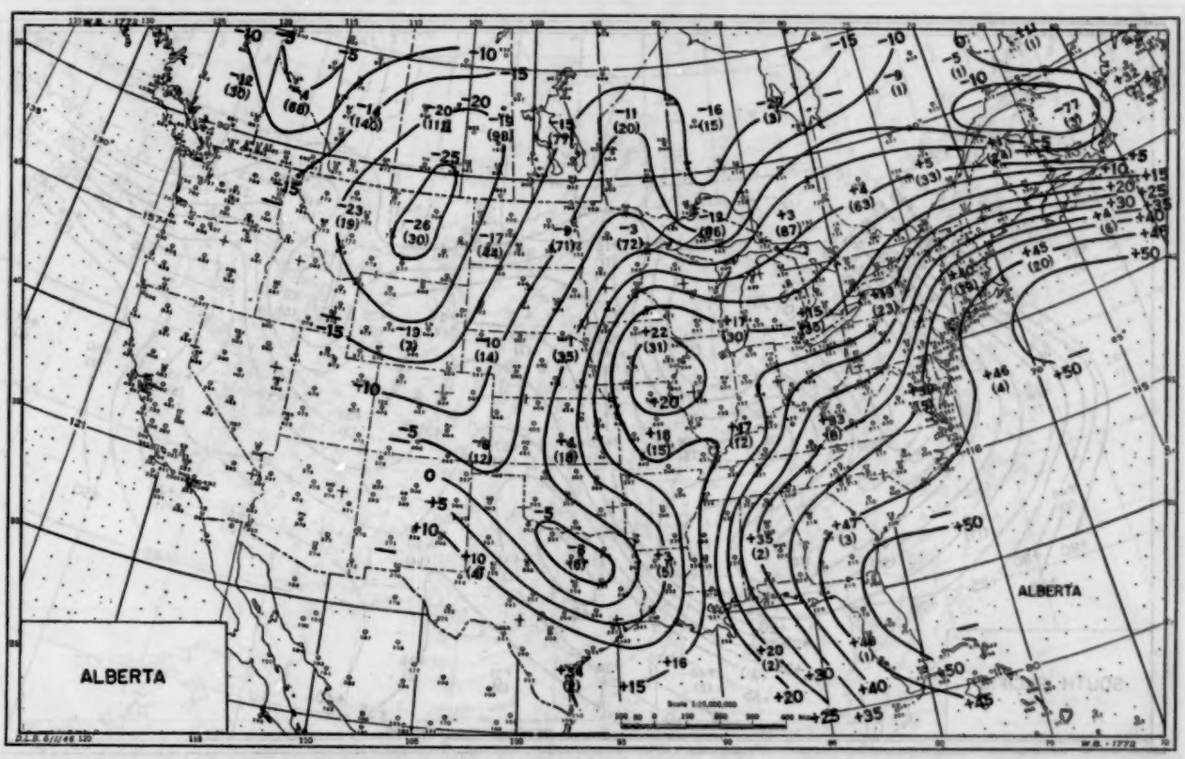

FIGURE 2.—Map showing isograms of average 24-hour direction of movement of winter cyclones, drawn from average direction of movement by 5° squares (shown by numbers), based on winter cases in Bowie and Weightman data (numbers in parentheses).

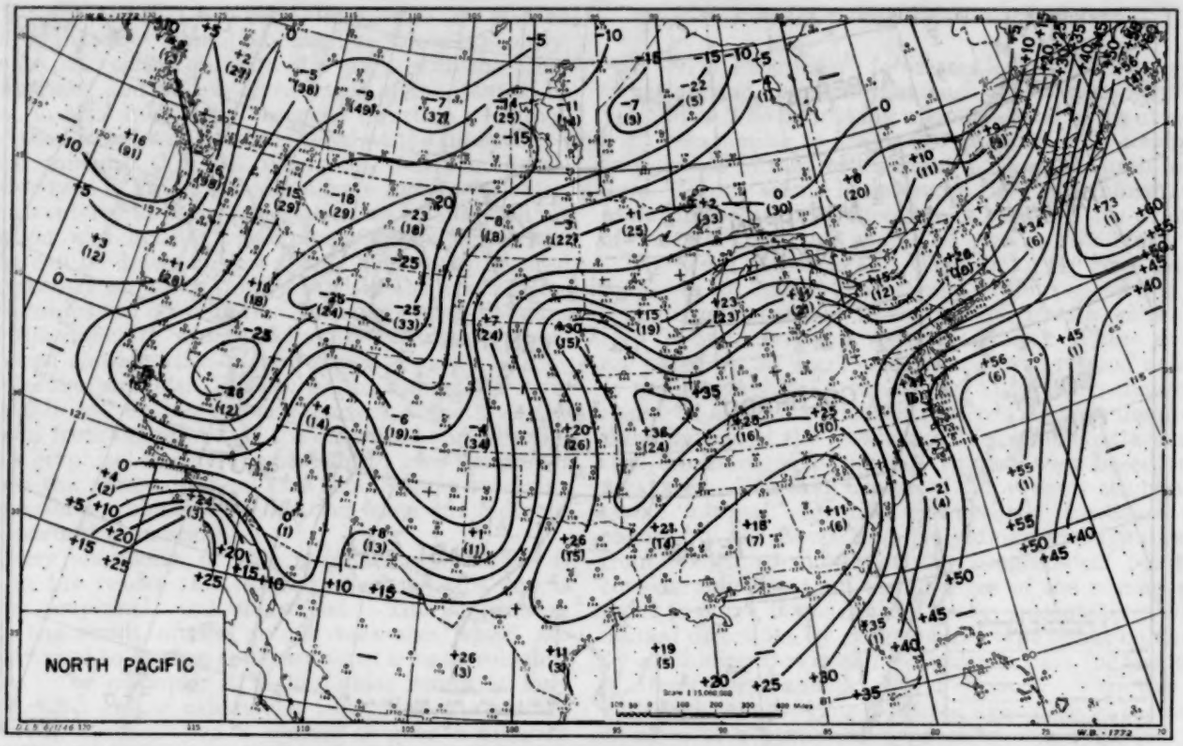

FIGURE 3.—Map showing isograms of average 24-hour direction of movement of winter cyclones, drawn from average direction of movement by 5° squares (shown by numbers), based on winter cases in Bowie and Weightman data (numbers in parentheses).

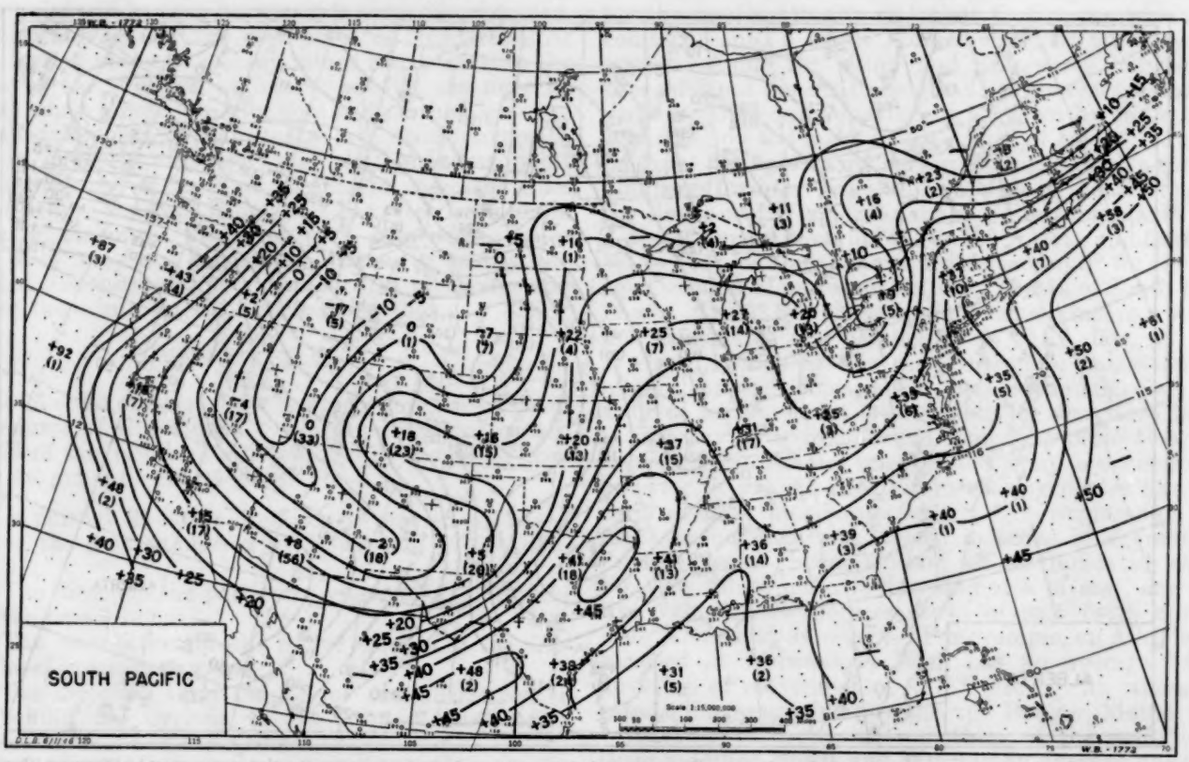

FIGURE 4.—Map showing isograms of average 24-hour direction of movement of winter cyclones, drawn from average direction of movement by 5° squares (shown by numbers), based on winter cases in Bowie and Weightman data (numbers in parentheses).

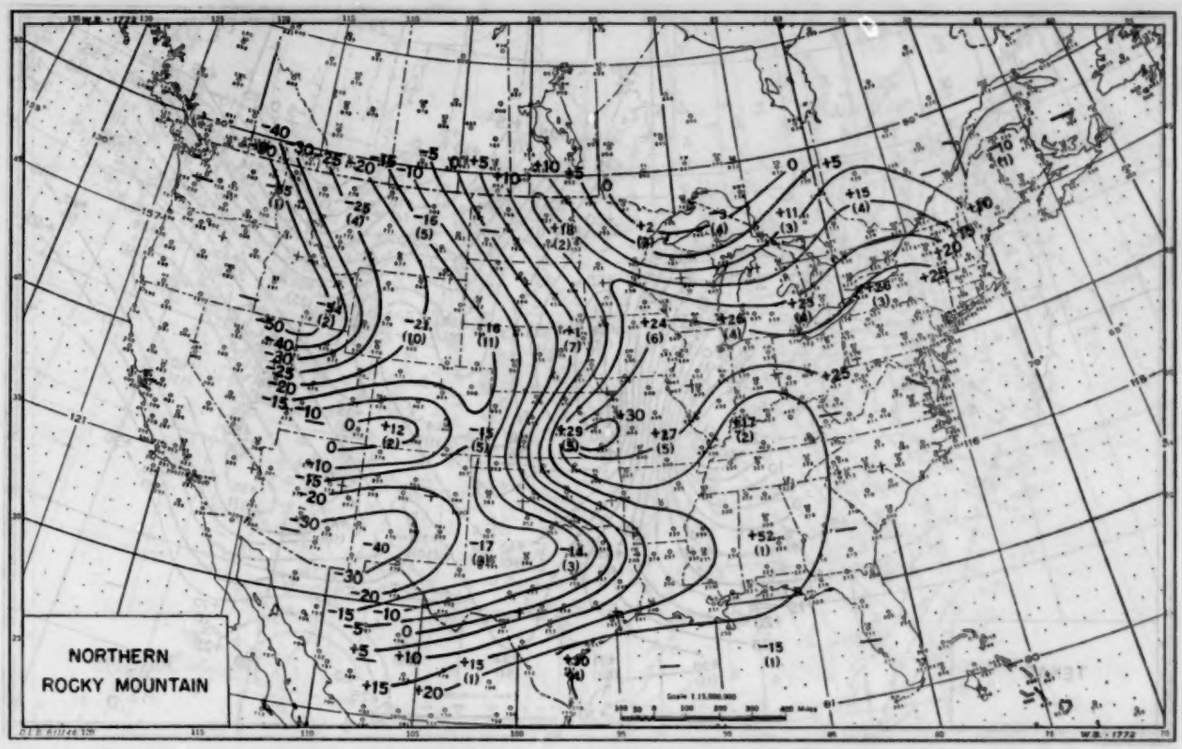

FIGURE 5.—Map showing isograms of average 24-hour direction of movement of winter cyclones, drawn from average direction of movement by 5° squares (shown by numbers), based on winter cases in Bowie and Weightman data (numbers in parentheses).

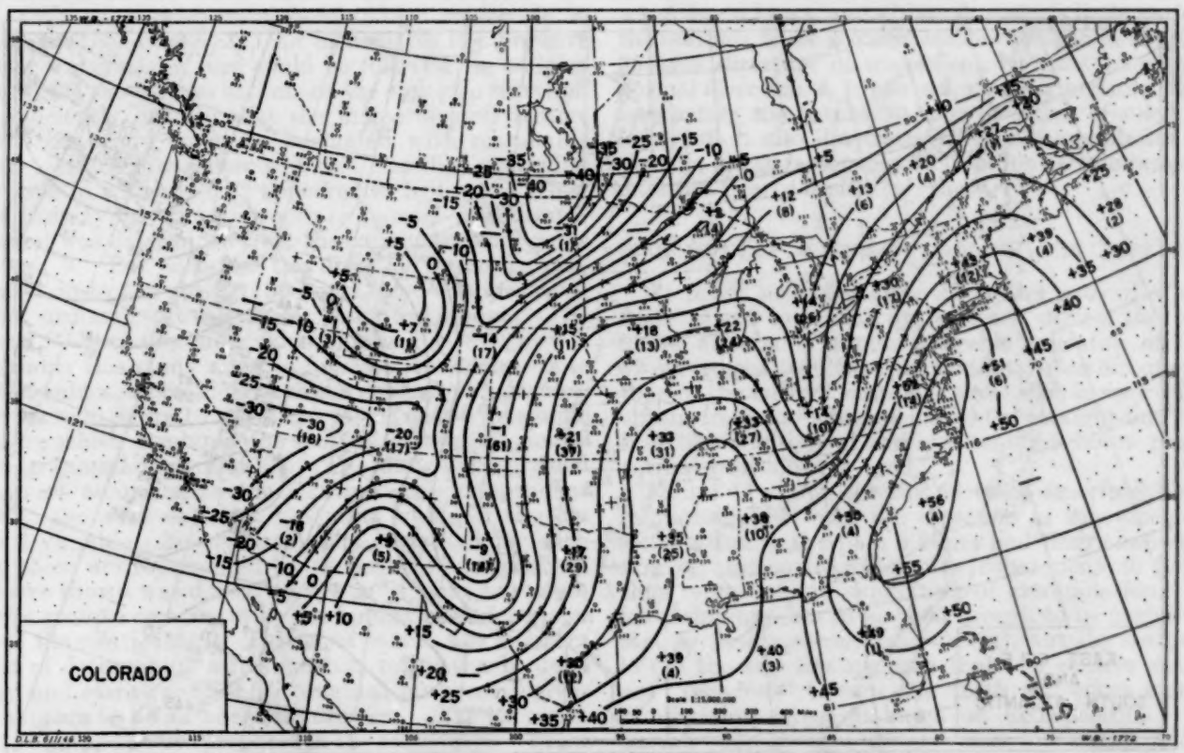

FIGURE 6.—Map showing isograms of average 24-hour direction of movement of winter cyclones, drawn from average direction of movement by 5° squares (shown by numbers), based on winter cases in Bowie and Weightman data (numbers in parentheses).

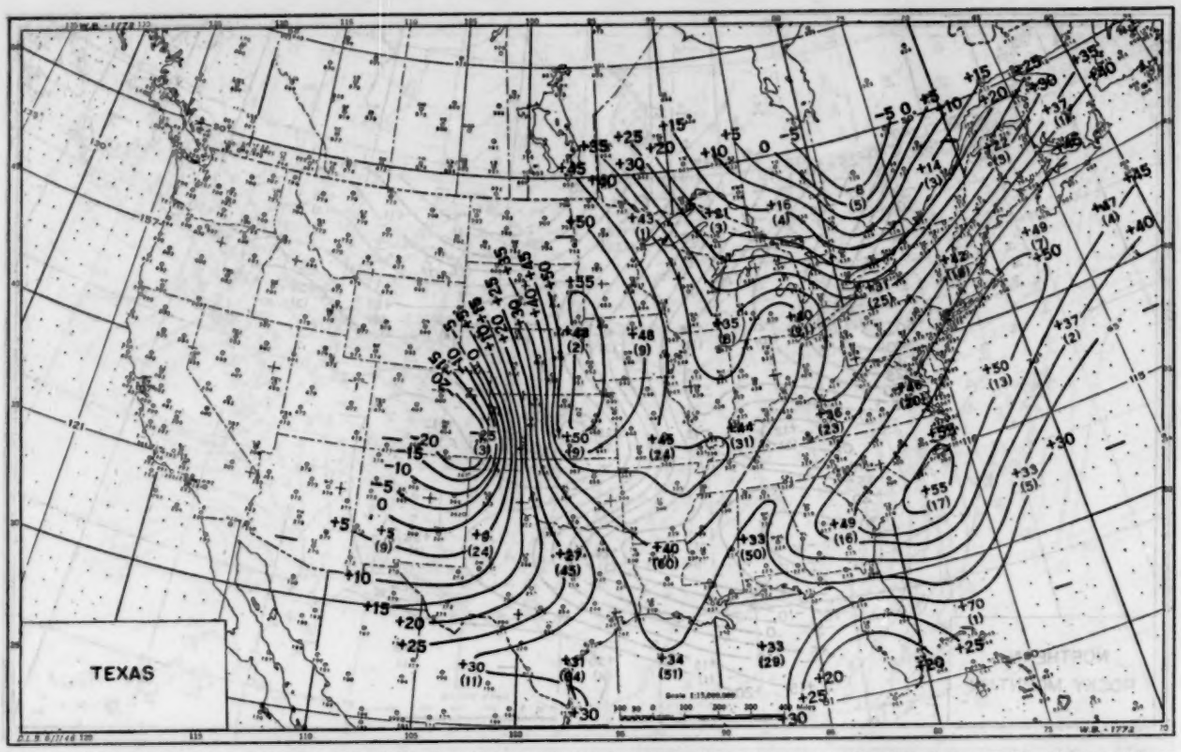

FIGURE 7.—Map showing isograms of average 24-hour direction of movement of winter cyclones, drawn from average direction of movement by 5 °squares (shown by numbers), based on winter cases in Bowie and Weightman data (numbers in parentheses).

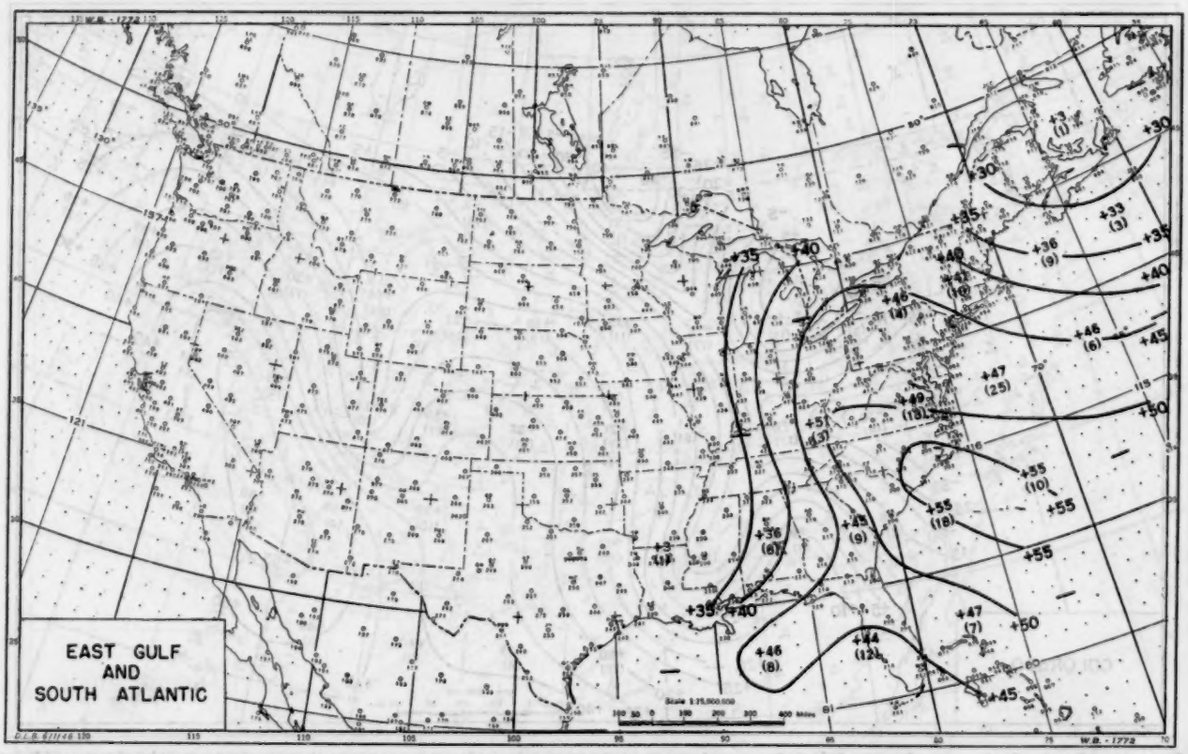

FIGURE 8.—Map showing isograms of average 24-hour direction of movement of winter cyclones, drawn from average direction of movement by 5° squares (shown by numbers), based on number of winter cases in Bowie and Weightman data (numbers in parentheses).

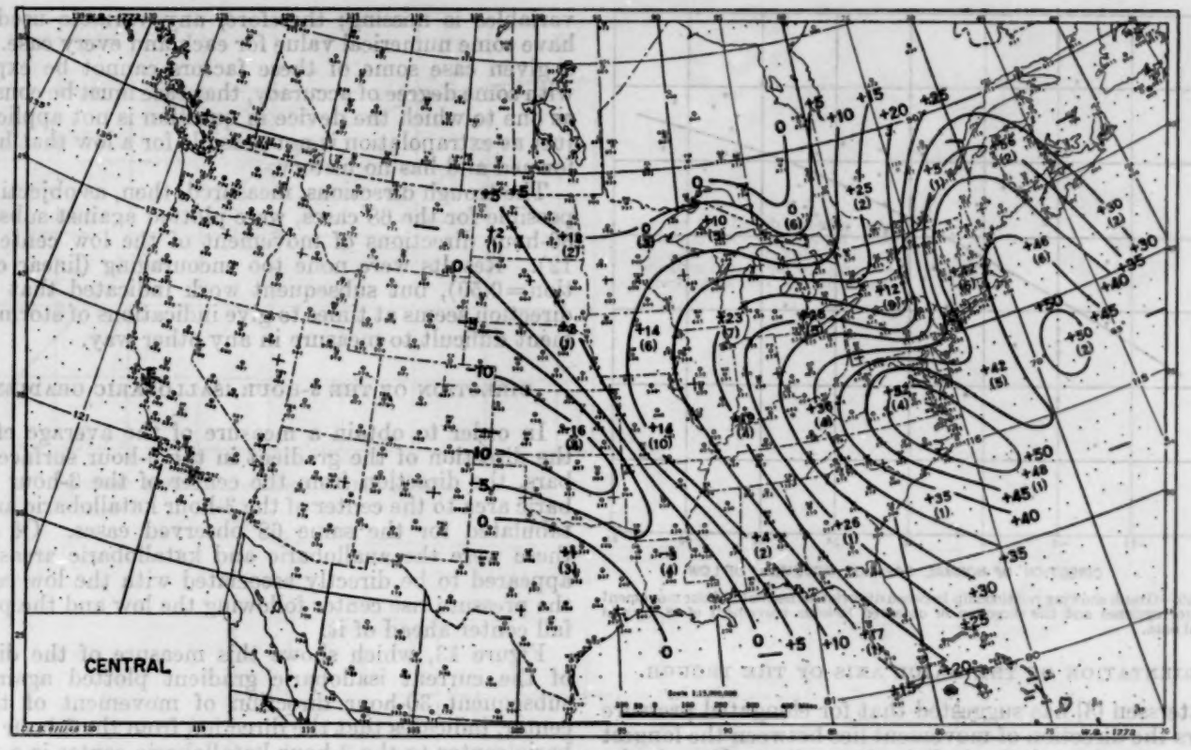

FIGURE 9.—Map showing isograms of average 24-hour direction of movement of winter cyclones, drawn from average direction of movement by 5° squares (shown by numbers), based on number of winter cases in Bowie and Weightman data (numbers in parentheses).

collected from the available weather maps of 1941 through 1945. Only those cases were chosen which conformed to the following conditions: (1) An identifiable low pressure center or wave existed and could be followed for at least 30 hours; (2) the various aspects of the synoptic situation were sufficiently definite that the meteorological factors used in this study could be evaluated with reasonable accuracy. Each low center was first classified according to the area in which it first appeared in figure 1. When it was thus typed, the appropriate normal direction of movement was determined from the correct map of figures 2 through 9. For each low the direction from the current position to the position 30 hours later was measured with an ordinary protractor, as described above. The observed 30-hour direction value obtained in this way is the variable this study aims to forecast; therefore, those observed values are considered as the dependent variables.

The curve in figure 10 was fitted to the data by a simple procedure which combines the method of average points with a graphical technique [2]. The data were divided into groups according to the values of the independent variable (the abscissa), and the mean value of the dependent variable (the ordinate) was computed for each group; these are represented by the crosses on figure 10. The curve shown was drawn by eye to fit what appeared, from the group averages, to be the approximate form and trend of the relationship. This is, of course, not an exact method of determining a relationship, but it can be done quickly and easily, and for all practical purposes it gives what appears to be an adequate answer. (The curves in figs. 11, 12, and 13 were prepared in the same way.) From the curves of figure 10 it is readily apparent that a relationship exists (linear correlation 0.64), but it is also apparent that forecasts based on normal direction alone would be unsatisfactory. Most of the cases with negative normals (i. e., those having a normal direction to the south of east) are Alberta Lows, and although there is little variation in the normals, there is considerable variation in the observed 30-hour direction of movement. Figure 10 shows that normal direction is, in general, a rather pertinent factor in forecasting the future 30-hour direction of movement of lows, but it also illustrates the condition alluded to previously, viz., a factor may be useful in certain ranges of the data but nearly useless in others.

DIRECTION OF MOVEMENT DURING THE PAST 6 HOURS

To many meteorologists the future path of a low is to some extent indicated by its track during the past few hours. Probably a more desirable indication of direction of movement would be the instantaneous direction at the time of the current map, but since that is very difficult to obtain from the weather maps, the straight-line direction from the position of the low center 6 hours past to its current position was used.

Figure 11 shows for the 68 cases described above the relationship between the direction of movement of low centers during the past 6 hours and their observed direction of movement during the subsequent 30 hours. It thus represents an evaluation of extrapolation. The relationship appears to be good enough to be useful for forecasting (linear correlation = 0.74), but the scatter to the left of the zero line suggests that low centers which have not "recurved" toward the north will cause most errors in direction forecasts based on extrapolation. (A "recurved" low is here defined as a low center which had moved to the north of east during the past 6 hours, i. e., the direction of movement during the past 6 hours is positive when measured in accordance with the previously described technique for measuring 30-hour movements.)

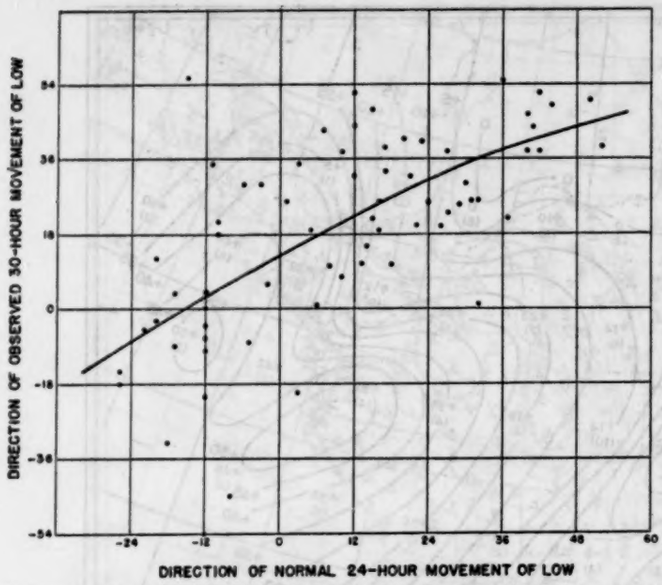

FIGURE 10.—Graph showing relationship between direction of normal 24-hour movement of winter cyclones and the direction of observed 30-hour movement of 68 lows in original data.

ORIENTATION OF THE MAJOR AXIS OF THE TROUGH

Petterssen [3] has suggested that for elongated pressure centers the direction of movement lies between the longest symmetry axis and the isallobaric gradient through the center. Initially, considerable time and effort were expended in this study to evaluate that rule. Various attempts were made to express the effectiveness of the direction of the major axis of a low center as a function of its degree of elongation. Some success was achieved, but the difficulties of measuring the lengths of the major and minor axes made the resultant charts subject to large errors; therefore, all attempts to make use of the degree of elongation were abandoned, and merely the orientation of the large-scale, over-all trough in the surface pressure pattern was used for trough direction and evaluated separately. The direction of elongation of the few innermost isobars of a given low center was discarded in favor of the orientation of the "valley" wherein the low center was found, usually between two or more rather extensive high pressure cells, In some respects, however, this item was rather unsatisfactory to evaluate, since there is sometimes a doubt as to which direction to call the trough direction. For example, with an Alberta Low in Kansas and a definite north-south trough, it would in some ways be no more logical to consider the trough direction as north from the center than south from it. In the majority of cases the direction which agreed closest with the direction of movement during the past 6 hours was chosen, although no exact rules were formulated and each case was considered rather subjectively. In those cases where the trough direction was too indistinct for trustworthy determination, the low center was considered to be circular, and the 3-hour isallobaric gradient (discussed in a later section) was substituted for trough direction. This substitution was somewhat arbitrary, but any device which systematically combines a number of variables into a "forecast" becomes useless if, and when, one of those variables is missing; therefore, any variable used must have some numerical value for each and every case. If in a given case some of these factors cannot be expressed with some degree of accuracy, that case must be considered as one to which the device in question is not applicable—just as extrapolation is not possible for a low that has just formed and has no history.

The trough directions, measured, then, as objectively as possible for the 68 cases, were plotted against subsequent 30-hour directions of movement of the low centers (fig. 12). Results were none too encouraging (linear correlation=0.59), but subsequent work indicated that trough direction seems at times to give indications of storm movement difficult to measure in any other way.

DIRECTION OF THE 3-HOUR ISALLOBARIC GRADIENT [2]

In order to obtain a measure of the average effect of the direction of the gradient in the 3-hour surface isallobars, the direction from the center of the 3-hour anallobaric area to the center of the 3-hour katallobaric area was tabulated for the same 68 observed cases. Of course, these were the anallobaric and katallobaric areas which appeared to be directly associated with the low center—the pressure rise center following the low and the pressure fall center ahead of it.

Figure 13, which shows this measure of the direction of the current isallobaric gradient plotted against the subsequent 30-hour direction of movement of the low center, indicates that the direction from the 3-hour anallobaric center to the 3-hour katallobaric center is a reasonably good first approximation of the direction the low center will move during the next 30 hours (linear correlation=0.72). It was one of the most useful factors found on the current synoptic charts.

Although this measure of direction of the isallobaric gradient was found to be highly correlated with the direction the low center had moved during the past 6 hours (linear correlation = 0.75), it nevertheless seemed to contain some independent information. Relatively high correlations such as this frequently exist among many of the aspects of a synoptic situation. Such correlations between supposedly independent variables add to the complexity of a forecasting problem by making it difficult to find independent measures of a synoptic situation.

COMBINATION OF VARIABLES

STRATIFICATION OF DATA

As the first step in combining the four variables—normal direction, past direction, trough direction, and isallobaric direction—into a single forecast, the data were stratified according to the direction of movement during the past 6 hours. As was pointed out in the previous discussion of that variable, its usefulness was less when applied to cases in which low centers had not recurved than to those which had recurved. Therefore, the 68 cases were stratified into two groups: those in which past 6-hour movement was 0° or in the negative direction (33 nonrecurved cases); and those in which the past 6-hour movement was in the positive direction (35 recurved cases).

[2] The possibility of applying this variable was inferred from the statements of Petterssen [2], and it was used at the specific suggestion of A. K. Showalter, who stated that his experience in forecasting the direction of movement of cyclones had shown the effectiveness of this measure of the field of 3-hour isallobars.

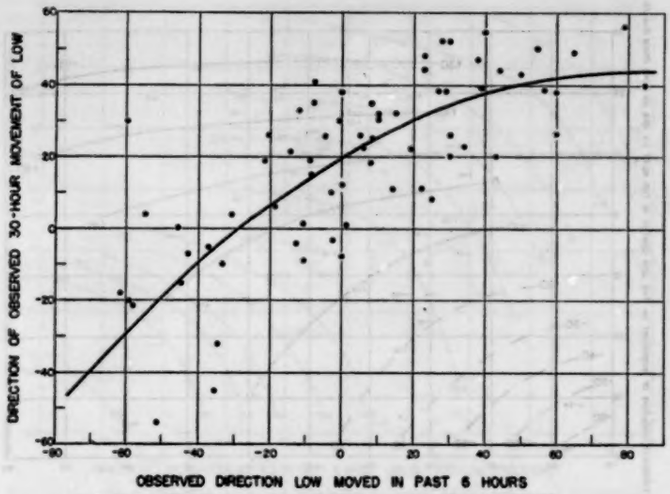

FIGURE 11.—Graph showing relationship between observed direction low moved in last 6 hours and direction of observed 30-hour movement for 68 lows in original data.

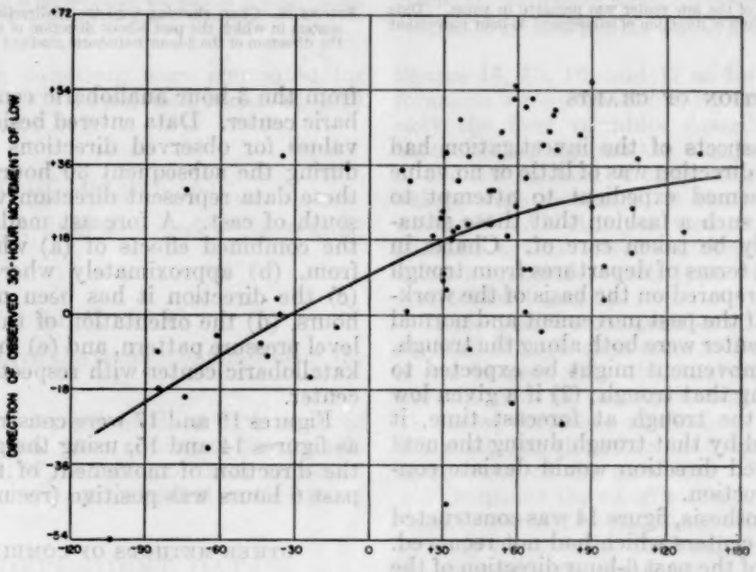

FIGURE 12.—Graph showing relationship between the measured direction of the over-all trough in the pressure pattern and the direction of observed 30-hour movement for 68 lows in original data.

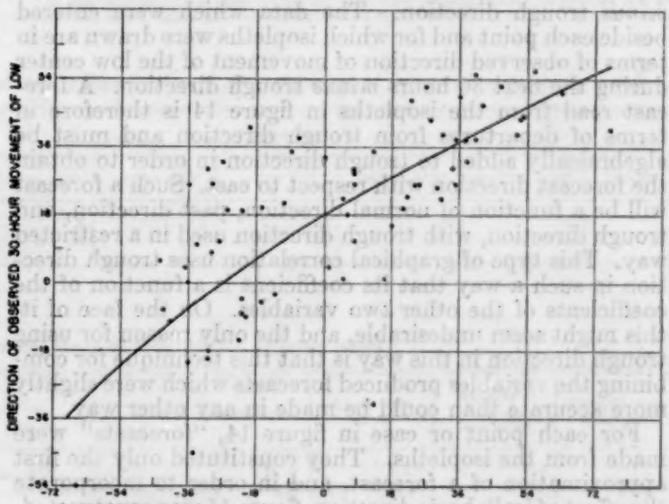

FIGURE 13.—Graph showing relationship between direction from the 3-hour anallobaric center to the 3-hour katallobaric center and the direction of observed 30-hour movement for 68 lows in original data.

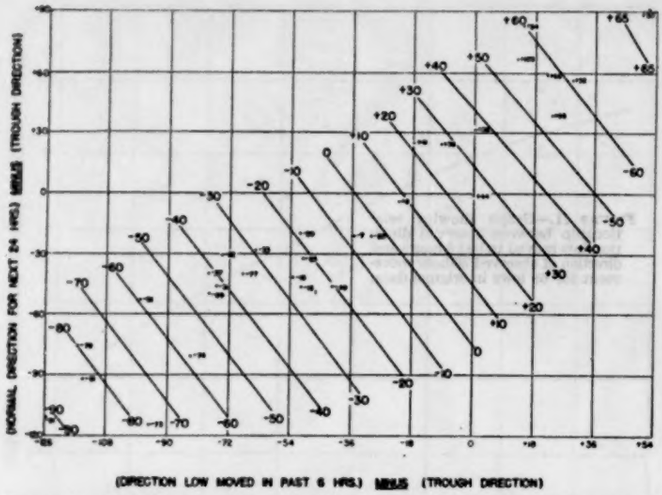

FIGURE 14.—Chart showing data and isopleths in terms of departures of subsequent 30-hour direction of movement of the lows from trough direction, for cases in which the past 6-hour direction of movement of the low center was negative in value. (Data entered beside plotted points are values of direction of subsequent 30-hour movement of low *minus* trough direction.)

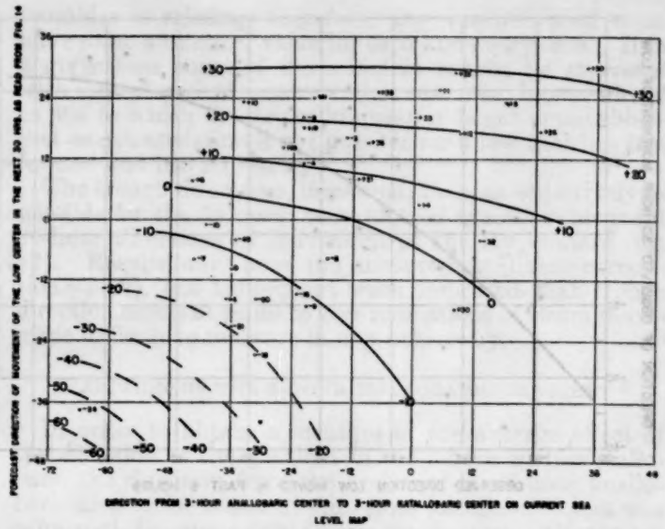

FIGURE 15.—Chart showing isopleths of direction of movement to be forecast for low centers in which the past 6-hour direction of movement was negative in value—with the direction of the 3-hour isallobaric gradient incorporated in the data.

CONSTRUCTION OF CHARTS

Inasmuch as certain aspects of the investigation had indicated that the trough direction was of little or no value in some situations, it seemed expedient to attempt to combine the variables in such a fashion that those situations would automatically be taken care of. Charts in which the data were all in terms of departures from trough direction were therefore prepared on the basis of the working hypothesis that: (1) If the past movement and normal direction for a given low center were both along the trough, the subsequent 30-hour movement might be expected to continue more or less along that trough; (2) if a given low were not moving along the trough at forecast time, it would not likely be guided by that trough during the next 30 hours, and the observed direction would deviate considerably from trough direction.

On the basis of this hypothesis, figure 14 was constructed using the 33 cases of low centers which had not recurved. The abscissa is the value of the past 6-hour direction of the center *minus* trough direction; the ordinate is the value for the 24-hour normal direction of movement of the center *minus* trough direction. The data which were entered beside each point and for which isopleths were drawn are in terms of observed direction of movement of the low center during the next 30 hours *minus* trough direction. A forecast read from the isopleths in figure 14 is therefore in terms of departures from trough direction and must be algebraically added to trough direction in order to obtain the forecast direction with respect to east. Such a forecast will be a function of normal direction, past direction, and trough direction, with trough direction used in a restricted way. This type of graphical correlation uses trough direction in such a way that its coefficient is a function of the coefficients of the other two variables. On the face of it, this might seem undesirable, and the only reason for using trough direction in this way is that this technique for combining the variables produced forecasts which were slightly more accurate than could be made in any other way.

For each point or case in figure 14, "forecasts" were made from the isopleths. They constituted only the first approximation of a forecast, and in order to incorporate the effect of isallobaric direction, figure 15 was constructed. The ordinate is the direction value obtained from figure 14, and the abscissa is the numerical value for the direction from the 3-hour anallobaric center to the 3-hour katallobaric center. Data entered beside each plotted point were values for observed directions of low center movement during the subsequent 30 hours. Isopleths drawn from these data represent direction values in degrees north or south of east. A forecast made from them incorporates the combined effects of (a) where the low center comes from, (b) approximately where it is at forecast time, (c) the direction it has been moving during the past 6 hours, (d) the orientation of the major trough in the sea level pressure pattern, and (e) the orientation of the 3-hour katallobaric center with respect to the 3-hour anallobaric center.

Figures 16 and 17 were constructed in the same manner as figures 14 and 15, using the group of 35 cases in which the direction of movement of the low center during the past 6 hours was positive (recurved classification).

OTHER METHODS OF COMBINING THE VARIABLES

In order to discover whether or not the variables could be combined in a more satisfactory manner, the following methods were used:

(1) All data (68 cases) were treated together graphically, with no stratification.

(2) A series of graphs was constructed using only three of the variables. (Trough direction was omitted, since construction of figures 14 and 15 indicated that it seemed to have little or no effect on the forecast in many cases, although in others it seemed to be significant.)

(3) A linear regression equation was computed for all data:

$$\theta^F_{0+30}=0.28\theta^I+0.31\theta^P+16.0°$$

This equation indicates that the forecast direction for the next 30 hours is 0.28 times the direction from the 3-hour pressure rise area to the 3-hour pressure fall area plus 0.31 times the direction the low center moved during the past 6 hours plus 16°. The value obtained is in degrees from east.

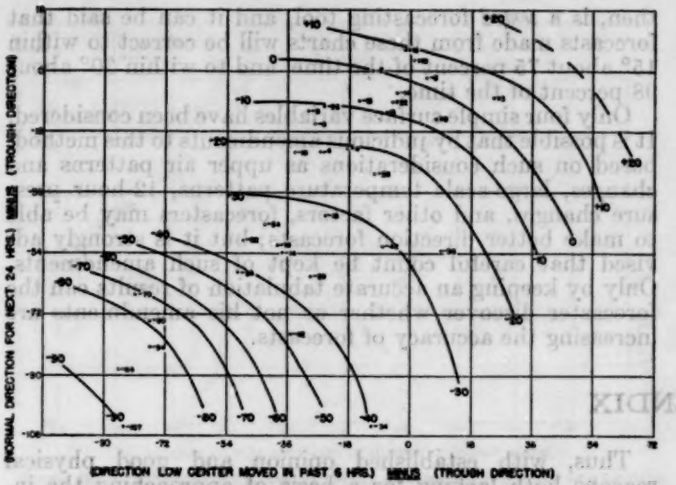

FIGURE 16.—Chart showing data and isopleths in terms of departures of subsequent 30-hour direction of movement of the lows from trough direction, for cases in which the past 6-hour direction of movement of the low center was positive in value. (Data entered beside plotted points are values of subsequent 30-hour movement of low *minus* trough direction.)

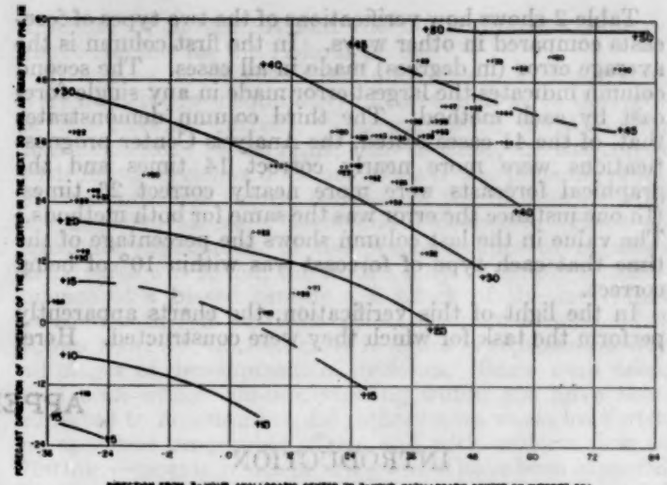

FIGURE 17.—Chart showing isopleths of direction of movement to be forecast for low centers in which the past 6-hour direction of movement was positive in value—with the direction of the 3-hour isallobaric gradient incorporated in the data.

(4) Linear regression equations were computed for the nonrecurved (33) cases, and recurved (35) cases, separately:
Nonrecurved:

$$\theta^{F}_{0+30}=0.29\theta^{T}+0.28\theta^{P}+0.38\theta^{N}+16.0°,$$

where θ^{T} is trough direction, and θ^{N} is normal direction.
Recurved:

$$\theta^{F}_{0+30}=0.24\theta^{t}+0.16\theta^{P}+23.0°,$$

where θ^{t} and θ^{P} have the same meanings as in (3) above.

Forecasts made using independent data with each of these systems were, in general, very similar to those made from figures 14, 15, 16, and 17, but none of them appeared to be quite as good as the system embodied in the use of those figures.

TESTS ON INDEPENDENT DATA

Forty-one cases of cyclones from the winters of 1946–47 and 1947–48 were used to independently test the value of figures 14, 15, 16, and 17 as forecasting tools. Direction forecasts were prepared using these charts, which included only the four variables described previously, and were then checked against the observed direction of movement of the low centers. For the sake of comparison, direction values were measured on the prognostic charts prepared by the WBAN Analysis Center for the same 41 cases and checked against observed directions of movement. Resultant errors for each type of forecast were tabulated (see tables 1 and 2).

Table 1 shows the number of the 41 cases tested which resulted in each class error.[3] For example, from the table it can be seen that the Analysis Center prognostications were in error in the amount of −6° to −15° in 9 of the 41 cases; forecasts made from the charts developed in this study, on the other hand, were in error in that amount in 10 cases of the 41 tested. The class interval −5° to +5° contains the cases tested in which the forecasts were "nearly perfect"—deviating from the observed direction by only 5° or less. It should be noted that 17 forecasts (41 percent) prepared by the graphical technique fell into the nearly perfect category.

[3] In the designations of class errors, negative error indicates that the forecast was for movement to the right of the movement which was observed.

TABLE 1.—*Table showing verification of two types of forecasts by indicating distribution of class errors in 41 independent forecasts tested*

Forecasts made by	Class error						
	>−30°	−16° to −30°	−6° to −15°	−5 to +5°	+6° to +15°	+16° to +30°	>+30°
Analysis center	3	3	9	9	10	5	2
Graphical technique	0	3	10	17	3	7	1

TABLE 2.—*Table showing verification data for two types of forecasts for 41 cases tested*

Forecasts made by	Average error	Maximum error	Number of cases with least error	Percent with error >11°
Analysis center	15.8°	−82°	14	54
Graphical technique	10.7°	+39°	26	63

Table 2 shows how verifications of the two types of forecasts compared in other ways. In the first column is the average error (in degrees) made in all cases. The second column indicates the largest error made in any single forecast by each method. The third column demonstrates that, of the 41 cases tested, the Analysis Center prognostications were more nearly correct 14 times and the graphical forecasts were more nearly correct 26 times. (In one instance the error was the same for both methods.) The value in the last column shows the percentage of the time that each type of forecast was within 10° of being correct.

In the light of this verification, the charts apparently perform the task for which they were constructed. Here, then, is a *tested* forecasting tool, and it can be said that forecasts made from these charts will be correct to within 15° about 75 percent of the time, and to within 30° about 98 percent of the time.

Only four simple surface variables have been considered. It is possible that by judicious amendments to this method, based on such considerations as upper air patterns and changes, large-scale temperature patterns, 12-hour pressure changes, and other factors, forecasters may be able to make better direction forecasts; but it is strongly advised that careful count be kept of such amendments. Only by keeping an accurate tabulation of results can the forecaster discover whether or not his amendments are increasing the accuracy of forecasts.

APPENDIX

INTRODUCTION

The purpose of this section is to present what might be called the "negative results" of the study. The first part of the paper has presented factors which were evaluated and finally combined into a forecasting tool; this section presents some of the other variables which were investigated but which either did not improve, or showed no promise of improving, the graphical forecasts based on the four surface variables. Each new variable under investigation was systematically combined with the existing set of graphical forecasts or with the items which went into those forecasts. If this combination led to "more nearly correct" results for the majority of the forecasts, the variable was considered an improvement. As the criterion of the results, "more nearly correct" meant that verification of forecasts made using the additional new variable showed fewer large errors and a smaller mean error for the total number of forecasts.

INVESTIGATIONS

STEERING [4]

The decision to investigate this factor brought with it the problem of method of approach. Little has been written about the term "steering," and its definition varies greatly in use by different forecasters. Among the differences is the variation of opinion of what constitutes the "steering level," with some forecasters believing that the flow pattern at some fixed upper level is the directing influence on the trajectories of surface disturbances, and other forecasters inclining toward choosing, by various means, a different level for each situation. In general it is considered to be some level or combination of levels between 850 and 300 mb., and in the cases of the fixed-level theory, it is believed to be something like the 700-mb. surface or the 500-mb. surface. Differences of opinion are also prevalent concerning the "steering current" at the steering level. Some forecasters look ahead of the closed low existing in the surface circulation and some look behind it for this current; there are those who consider the large-scale broad current in the region of the closed cyclonic circulation and others who consider the flow on only the warm-air side or on the cold-air side to be important. With this diversity of opinion on the concept of steering, it can only be concluded that steering if it is operative, has yet to be explained.

Thus, with established opinion and good physical reasons both lacking for a basis of approaching the investigation of steering in any particular manner, it was decided that the method of attack must be somewhat empirical. The first step was based on a suggestion by Austin [5] that cyclones which are being steered will continue to be steered and vice versa; this seemed a logical starting point in preparing to use the data to indicate when to consider steering as a factor and when to discredit it. In order to test this idea, the procedure finally formulated was to relate the following three factors by a graphical method similar to that of the earlier section of the paper: (a) Departure in direction of past 12-hour movement of the surface low from the direction of orientation of the upper-level contours above it at the beginning of that period; (b) departure of observed subsequent 30-hour direction of movement of the surface low from the orientation of the upper-level contours above it at the beginning of that period; (c) orientation of the upper contours. Both the 500- and 700-mb. levels were used in the plotting, inasmuch as the most satisfactory level for investigation was not known.

Figure 18 is the graph showing the attempt to relate these values of departures from past 12-hour steering to

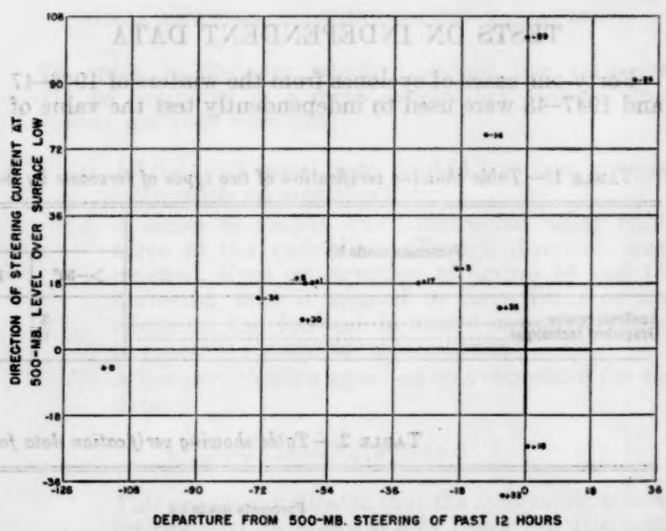

FIGURE 18.—Graph showing attempt to relate values of departures from past 12-hour steering to the departures from steering of the next 30 hours and to the direction of the steering current at 500 mb. directly above the surface low. (Values appearing beside plotted points represent departures from 30-hour steering.)

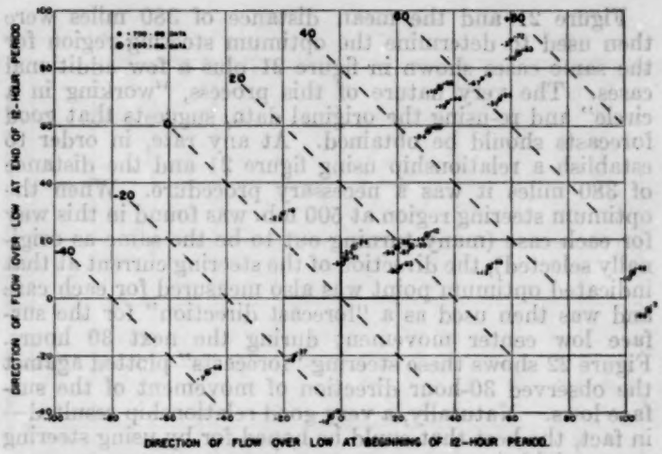

FIGURE 19.—Graph showing direction of 12-hour movement of low center as a function of winds above the low center at the beginning and ending of the 12-hour period. (Data entered above and to the right of plotted points represent values for the 12-hour direction of movement; values below and to the left indicate the difference between the observed direction of movement and the mean direction of flow above the low for the 12-hour period.)

departures from the steering of the next 30 hours and to the direction of the steering current at 500 mb. directly above the surface low. Data entered beside each plotted point are departures from the 30-hour steering. From these, it is apparent that the 30-hour departure value does not seem to be particularly well related to the direction of the 500-mb. steering current, and even less related to the departure from past 12-hour steering. The few plotted data do suggest that lows which followed a steering current at 500 mb. for the past 12 hours (a) continued to follow it during the subsequent 30-hour period when the steering current was directed approximately northeast; (b) departed from 20° to 30° to the right when the steering current was directed to the north; (c) departed 20° to 30° to the left when the steering current was directed toward about east to southeast. A relationship does seem to exist among the three factors, but these few data gave little promise of improving the established graphical forecast technique based on surface parameters only. Even if as many additional cases were plotted on the graph of figure 18 as are now shown, and it were found that for those additional cases 30-hour steering departures were an exact function of past 12-hour steering departures (in itself a very unlikely condition), when they were added to the data already plotted the over-all relationship would still not be particularly good. A graph similar to figure 18 was prepared from 700-mb. data but appeared to be no more promising than this graph from 500-mb. data.

When this first attempt at systematizing the use of steering as a variable had failed, figure 19 was constructed —not as a possible forecasting tool, but as an attempt to find out something about the concurrent relationship between upper-level flow patterns and direction of movement of the surface low center. Only the 12-hour movement of the low center was considered. Figure 19 shows this 12-hour direction of movement as a function of the winds above the low center at the beginning of the period (abscissa) and at the end of the period (ordinate). Data entered above and to the right of each point represent the observed values for the 12-hour direction of movement. The lines drawn sloping upward toward the left represent simply the mean direction of flow above the low during the period, i. e., the arithmetic mean of the ordinate and abscissa at each point. Values below and to the left of each point indicate the difference between the observed direction of movement and the mean direction of flow above the low for the 12-hour period.

It will be noted that these differences, or departures, were negative in the majority of cases, that is, to the right of the steering current. The suggestion of Weiss [6] that departures to the right, such as these, are associated with filling cyclones does not explain the preponderance of these negative values, because, of the 16 lows showing the negative values, 7 filled and 9 deepened. Since no adequate explanation of the preponderance of negative departures was found, the results may be simply a consequence of a biased sample. A check of the individual cases of both 700- and 500-mb. data which were included shows, however, that the cases in figure 19 represent nearly all stages of development of cyclones. Some were deep, cold lows where 700-mb. steering would not have been expected to function but did; others were warm lows with no apparent orographic effects and with uniform flow at 700 mb.—cases in which steering would have been expected to operate but apparently did not; one or two cases seemed to follow very closely the principle outlined by Oliver [7]. Results for the 20 cases were, on the whole, disappointing. For the total number the mean departure from steering was 33°; for the seven 700-mb. cases it was 34°; and for the thirteen 500-mb. cases it was 32°.

These results suggested that forecasts of direction of movement of lows cannot be made satisfactorily by considering only the direction of flow above the surface low center—even if that direction could be known in advance at a number of times during the forecast period. Attention was then directed to another aspect of steering. Since so many different ideas seem to exist concerning *where* to look for the steering current, an attempt was made to use the data to answer that question. The plan was to use the data to establish an "optimum" steering region at some level. The 500-mb. level was chosen for study more or less arbitrarily.

The position of each surface low center was plotted on the 500-mb. chart available at the time that low existed, and a line was drawn from that position (at forecast time) to the observed position of the same low 30 hours later. Then the area around the point marking the position of the current low was inspected in order to locate a region on the 500-mb. chart which would give the correct steering direction for the next 30-hour movement. The direction and distance from the low center to the center of this optimum steering region were recorded for each case. In the polar diagram of figure 20, the distribution of these optimum steering regions is shown with respect to the current position of the surface low centers. From the diagram it is readily apparent that no specific region is the place to look to get the proper steering direction; so the next step in the empirical approach was to try to relate the position of this optimum steering region at 500 mb. to other features of the current synoptic situation.

The distance from the low center to the optimum steering region was not found to be related to (1) direction to steering region, (2) speed of steering current, (3) direction of movement of the surface low center during the past 6 hours, nor to anything else that could be found. Therefore, the mean of all distances was obtained and used. That was about 380 miles from the position of the surface low.

The direction from the low center to the optimum steering region was also plotted against various measures of the current synoptic situation, including those mentioned above. Finally, a somewhat satisfactory geographical distribution was found. (There seemed to be no physical reason why this factor should be related to anything in

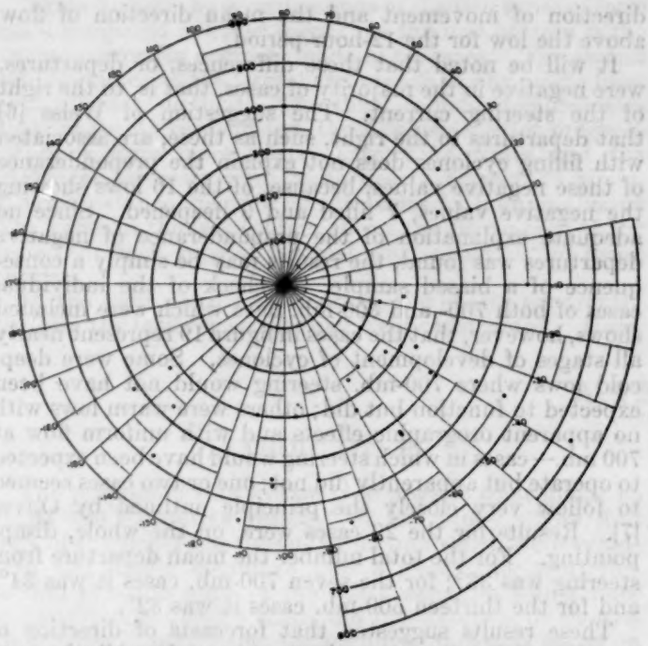

FIGURE 20.—Polar diagram showing distribution of optimum steering regions with respect to current positions of surface low centers.

particular.) The distribution is shown on the map of figure 21, for which the points were located according to the current position of the surface low center. If this relationship is real, it might be explained on the basis that lows in a certain position tend to have a normal direction of movement and *tend* to be accompanied by certain patterns at 500 mb. Therefore, the relationship, if any, may be of a climatological character.

Figure 21 and the mean distance of 380 miles were then used to determine the optimum steering region for the same cases shown in figure 21 plus a few additional cases. The very nature of this process, "working in a circle" and re-using the original data, suggests that good forecasts should be obtained. At any rate, in order to establish a relationship using figure 21 and the distance of 380 miles it was a necessary procedure. When the optimum steering region at 500 mb. was found in this way for each case (many turning out to be the same as originally selected), the direction of the steering current at that indicated optimum point was also measured for each case and was then used as a "forecast direction" for the surface low center movement during the next 30 hours. Figure 22 shows these steering "forecasts" plotted against the observed 30-hour direction of movement of the surface lows. Naturally, a very good relationship resulted—in fact, the best that could be hoped for by using steering as a variable.

The remaining step in this phase of the study of steering was to combine the forecast values obtained in the 53 cases plotted in figure 22 with the forecast values for the same cases as derived from figures 14, 15, 16, and 17 (the graphical technique developed in the first section of the paper). Figure 23 shows these two different forecast values plotted one against the other. Data which were entered beside each point and for which isopleths were drawn are the values for the observed 30-hour direction of movement of the lows. The shape and slope of the isopleths show that, in general, the two forecasts have about equal weight. The average residual from figure 23 is 8.8°, whereas the average residual from figures 15 and 17 is 10.0°. This would appear to be a satisfactory improvement in terms of the forecast, but a test using 22 independent cases indicated that the "progress" was negative.

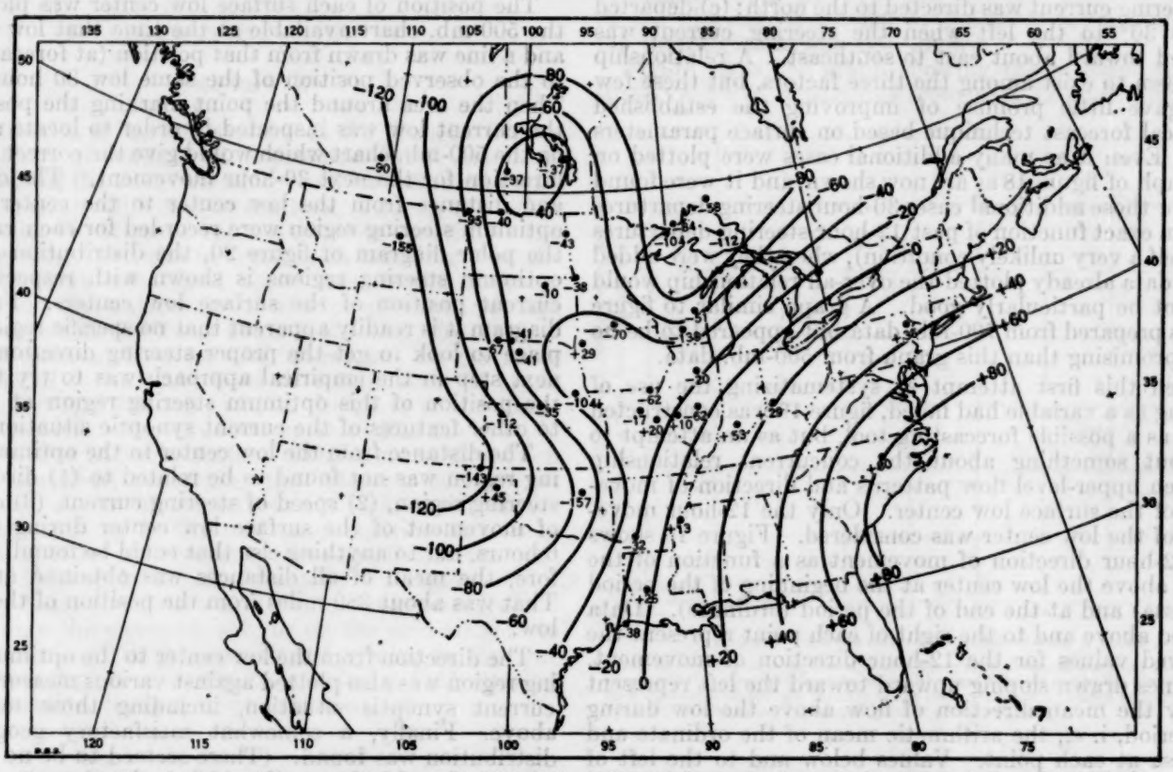

FIGURE 21.—Map showing isopleths representing geographical distribution of directions from surface low center to optimum steering point at 500 mb.

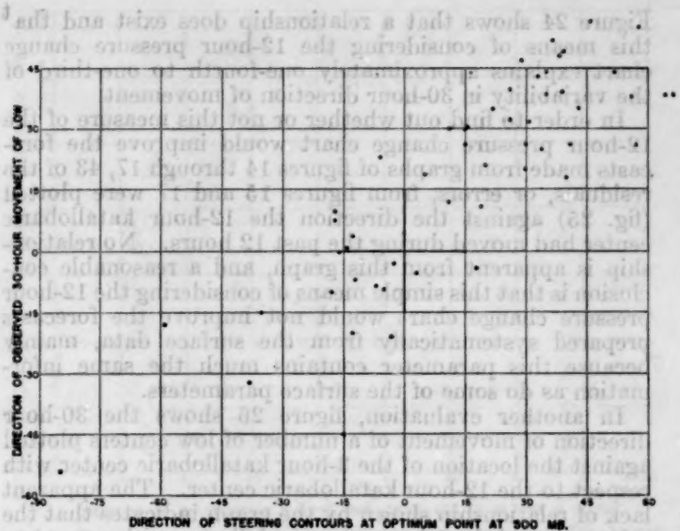

FIGURE 22.—Graph showing direction of steering contours at optimum point at 500 mb. plotted against the observed direction of 30-hour movement of low centers.

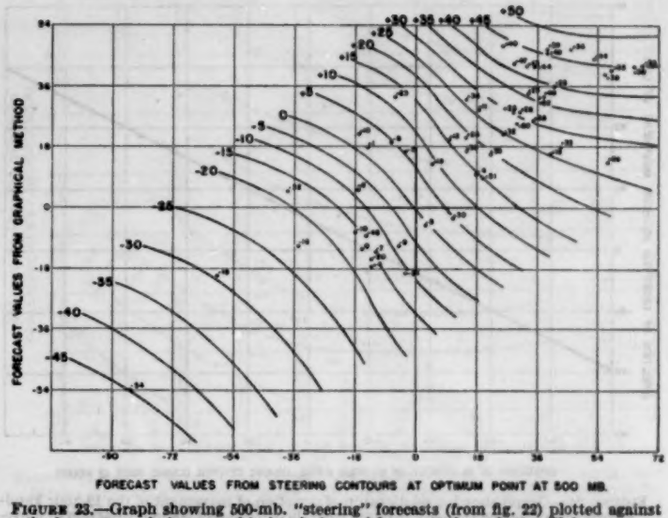

FIGURE 23.—Graph showing 500-mb. "steering" forecasts (from fig. 22) plotted against the forecasts made from graphical technique of figures 14 through 17. (Values appearing beside plotted points represent observed 30-hour direction of movement of the lows.)

This independent test was carried out using 22 of the independent cases that were used to obtain the results shown in figure 18. Figure 21 was used to find the direction from the surface low to the optimum steering region at 500 mb., and the distance of 380 miles was used to determine the exact point. Steering direction was measured at that point. The abscissa of figure 23 was entered with this value and the ordinate entered with the graphical forecast value based on surface data; the forecast direction of movement of the surface low during the next 30 hours was then read from the isopleths on figure 23. The average error for the 22 forecasts thus obtained was 13.5°, whereas the average error for the same 22 cases was only 10.4° when the graphical forecast from surface data was used alone. Of those 22 forecasts, 6 were improved by using 500-mb. steering in addition to surface indications; 3 were not changed; and 13 were made worse. In fact, in any way in which a verification was made, the forecasts had, in general, been made worse by the addition of steering; so the only conclusion that could be drawn was that forecasts made using figures 14 through 17 (based on surface data only) were not improved by using the 500-mb. data in this way.

Various other attempts were made to use steering systematically, but all results were disappointing. One attempt that appeared promising when used on dependent data was the combination of the graphical forecast from surface data and a steering forecast made using the 500-mb. contours 800 miles ahead of the surface low at a point on the line obtained by using the graphical forecast from surface data. However, when tested on independent data, this too failed to improve the original forecasts. Data were also examined in an attempt to justify the practice of many forecasters who use steering as an indicator only when certain conditions hold, such as when the upper winds are stronger than some arbitrary value. However, the data examined did not justify this rule, as steering seemed about the same with strong winds as it did with light winds.

This investigation does not prove that steering at some upper level is not related to the future direction of movement of the surface low center; on the contrary, it proves that a relationship does exist, but it strongly suggests that the relationship is not good enough to improve the forecasts which one can make by systematic use of the four surface factors—namely, normal direction for the next 24 hours, direction of movement of the surface center during the past 6 hours, direction from the 3-hour anallobaric center to the 3-hour katallobaric center, and orientation of the major over-all trough in the sea-level pressure pattern. It is apparently true that the surface low and the upper winds generally move more or less in the same direction, but in many cases the deviation is more than 30°, and any forecast that misses the direction of movement of the low by such an amount is an unsatisfactory forecast if the low moves appreciably. One should conclude, simply from an inspection of figure 19, that such an inadequate concurrent relationship can hardly be expected to improve forecasts when an arbitrary lag of 24 to 30 hours is imposed.

In conclusion, although there are many ways to consider steering that were not investigated, the work done shows rather convincingly that, in general, the forecasts which can be made using the four surface parameters named above cannot be improved by the systematic use of the steering flow at some upper level.

12-HOUR PRESSURE CHANGE AT SEA LEVEL

Many forecasters use the 12-hour pressure change chart to a considerable extent. Precisely how it is used to assist them in forecasting the 30-hour direction of movement of cyclones cannot be stated in a few words, because each forecaster uses it in his own way. In general, however, it may be said that its use involves extrapolating the areas of 12-hour pressure change and superimposing these extrapolated areas on the existing pressure patterns. By any graphical technique such as was used in this study, it is impossible to evaluate exactly the same features which the forecaster uses subjectively; however, it is possible to evaluate certain specific features of the 12-hour pressure change chart.

It was suggested that the direction of movement of the 12-hour katallobaric center during the past 12 hours should be related to the subsequent 30-hour direction of movement of the low center with which it was associated.

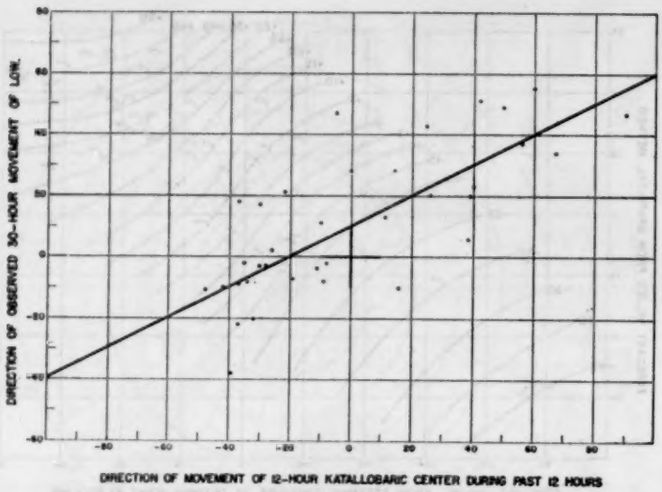
DIRECTION OF OBSERVED 30-HOUR MOVEMENT OF LOW
DIRECTION OF MOVEMENT OF 12-HOUR KATALLOBARIC CENTER DURING PAST 12 HOURS

FIGURE 24.—Graph showing relationship of direction of movement of the 12-hour katallobaric center during the past 12 hours with the subsequent 30-hour direction of movement of the low center associated with it.

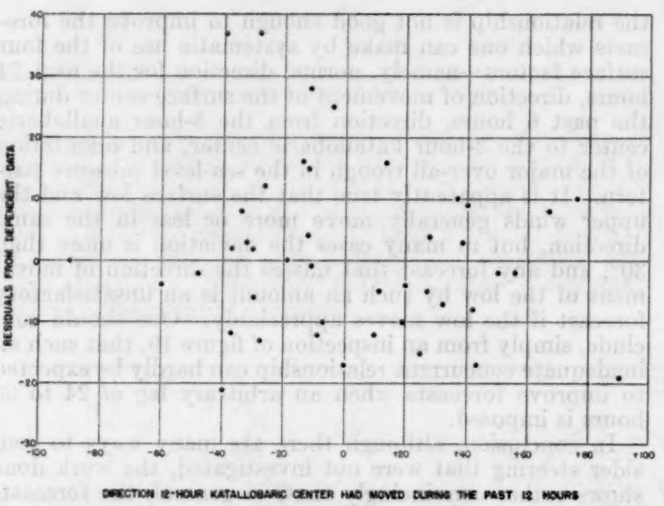

FIGURE 25.—Graph showing relationship between residuals from forecasts made by graphical technique with direction the 12-hour katallobaric center had moved during the past 12 hours.

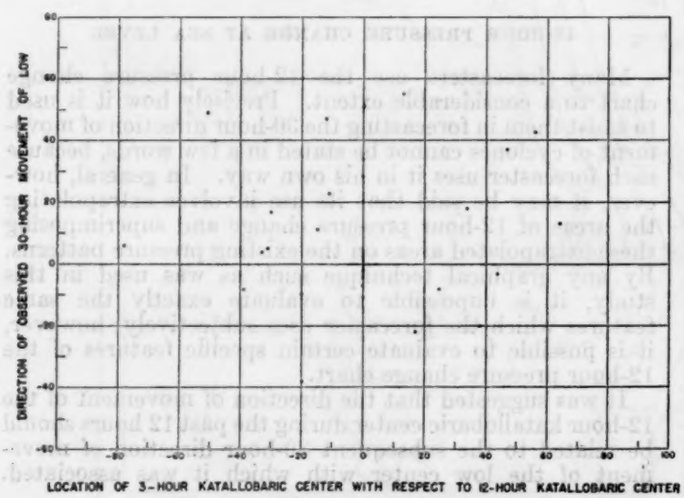
DIRECTION OF OBSERVED 30-HOUR MOVEMENT OF LOW
LOCATION OF 3-HOUR KATALLOBARIC CENTER WITH RESPECT TO 12-HOUR KATALLOBARIC CENTER

FIGURE 26.—Graph showing relationship between the location of the 3-hour katallobaric center with respect to the 12-hour katallobaric center and the direction of observed 30-hour movement of the low centers.

Figure 24 shows that a relationship does exist and that this means of considering the 12-hour pressure change chart explains approximately one-fourth to one-third of the variability in 30-hour direction of movement.

In order to find out whether or not this measure of the 12-hour pressure change chart would improve the forecasts made from graphs of figures 14 through 17, 43 of the residuals, or errors, from figures 15 and 17 were plotted (fig. 25) against the direction the 12-hour katallobaric center had moved during the past 12 hours. No relationship is apparent from this graph, and a reasonable conclusion is that this simple means of considering the 12-hour pressure change chart would not improve the forecasts prepared systematically from the surface data, mainly because this parameter contains much the same information as do some of the surface parameters.

In another evaluation, figure 26 shows the 30-hour direction of movement of a number of low centers plotted against the location of the 3-hour katallobaric center with respect to the 12-hour katallobaric center. The apparent lack of relationship shown by the graph indicates that the orientation of the 3-hour pressure fall area with respect to the 12-hour pressure fall area is not pertinent information for forecasting 30-hour direction of movement of winter cyclones.

The other aspect of the 12-hour pressure change chart which was tested individually was the direction the 12-hour anallobaric center had moved during the past 12 hours. Figure 27, plotted to test this, shows that probably no significant relationship exists between this factor and the subsequent 30-hour direction of movement of the associated low center.

Since the subsequent direction of movement of the low center seemed to be related to the past movement of the 12-hour katallobaric center (see fig. 24), it seemed logical to surmise that the departure of the subsequent direction of movement of the low from the past 12-hour direction of movement of the 12-hour katallobaric center might be related to (a) the direction the 12-hour anallobaric center had moved during the past 12 hours (ordinate in fig. 28) and/or (b) the orientation of the line between the 12-hour anallobaric center and the 12-hour katallobaric center (abscissa in fig. 28). To find this relationship figure 28 was plotted, with the departure of the direction of subsequent 30-hour movement of the low from the direction of past 12-hour movement of the 12-hour katallobaric center entered beside each plotted point. There does seem to be a tendency for positive departures to be located on the left side of the chart, and vice versa. This indicates that departures are related to the relative orientation of the 12-hour rise and fall areas rather than to past movement of the 12-hour rise area. Therefore, figure 29 was constructed, substituting the past direction of movement of the 12-hour katallobaric center as the ordinate. Data entered beside each case and for which isopleths were drawn are the same as in figure 28. For the 34 cases plotted in figure 29, the average bias is nearly zero. For the same 34 cases, from figures 14 through 17, the average residual was 9.4°. In comparison, 12 of the residuals from figure 29 are 15° or greater, while only 9 of the residuals from figures 14 through 17 are 15° or more.

Even though figure 29 does not appear to fit the data as well as do figures 14 through 17, the possibility existed that some of the errors which were made using the latter figures could be accounted for by the forecast made from figure 29. To test this, figure 30 was plotted, showing the residuals from the graphical forecasts made from dependent surface data plotted against forecasts made from figure 29, i. e., from the 12-hour pressure change

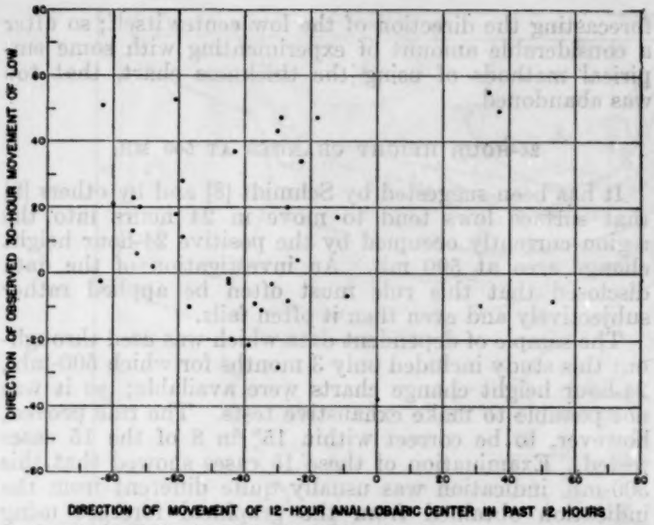

FIGURE 27.—Graph showing relationship between direction of movement of the 12-hour anallobaric center and the direction of observed 30-hour movement of the low center associated with it.

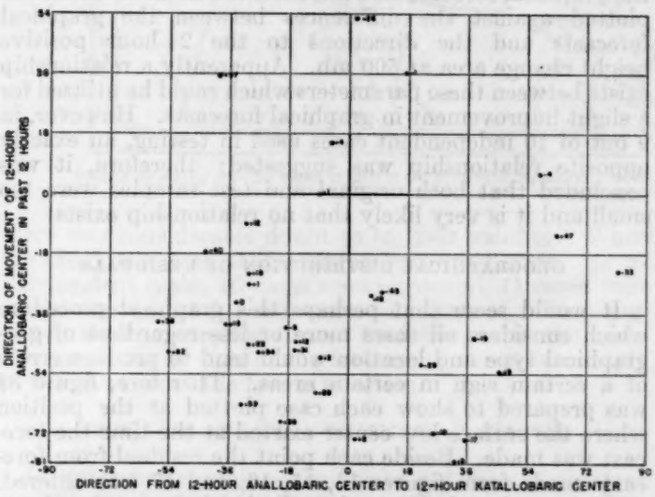
DIRECTION OF MOVEMENT OF 12-HOUR ANALLOBARIC CENTER IN PAST 12 HOURS
DIRECTION FROM 12-HOUR ANALLOBARIC CENTER TO 12-HOUR KATALLOBARIC CENTER

FIGURE 28.—Graph showing departures (data plotted beside each point) of subsequent 30-hour direction of movement of lows from past 12-hour direction of movement of the 12-hour katallobaric center as a function of (a) the direction of past 12-hour movement of the anallobaric center, and (b) the orientation of the line between the 12-hour anallobaric center and the 12-hour katallobaric center.

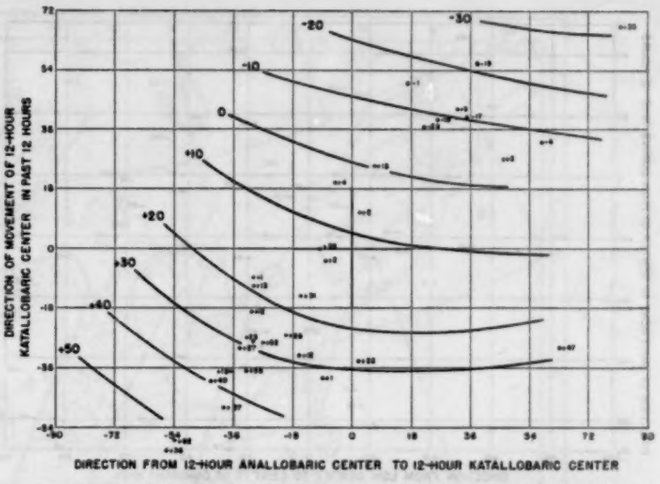
DIRECTION OF MOVEMENT OF 12-HOUR KATALLOBARIC CENTER IN PAST 12 HOURS
DIRECTION FROM 12-HOUR ANALLOBARIC CENTER TO 12-HOUR KATALLOBARIC CENTER

FIGURE 29.—Graph showing departures (data plotted beside each point) of subsequent 30-hour direction of movement of lows from past 12-hour direction of movement of the 12-hour katallobaric center as a function of (a) the direction of past 12-hour movement of the 12-hour katallobaric center, and (b) the orientation of the line between the 12-hour anallobaric center and the 12-hour katallobaric center.

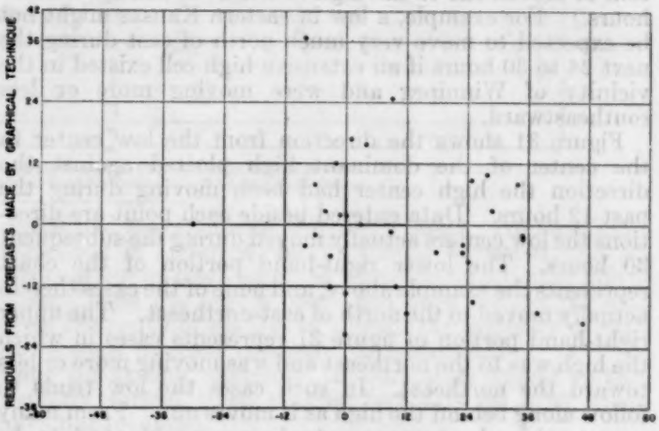

FIGURE 30.—Graph showing residuals from forecasts made from figures 14 through 17 plotted against forecasts made from figure 29.

chart data. No significant regression was apparent, and therefore, the information from the 12-hour pressure change chart was simply a duplication of the information which went into figures 14, 15, 16, and 17, and did not improve the original graphical forecasts. This sort of duplication of information seems to be characteristic of meteorological phenomena; the various aspects of a current synoptic situation are so interrelated that it is possible to get a given answer in many different ways from many different aspects of the situation.

Many other attempts were made to use the 12-hour pressure change chart systematically in forecasting the direction of movement of low centers. Although certain aspects of the chart were found to be related to the subsequent direction of movement of cyclones, no means of improving the graphical forecasts made from surface data were found.

"DOMINANT ANTICYCLONES" AT SEA LEVEL

It frequently appears from an inspection of a series of synoptic surface charts that the movement of a given cyclone is being affected to a considerable extent by the relative position and movement of some nearby anticyclone—an effect referred to as "blocking" in certain types of situations. Considerable effort was made to systematize this seeming effect, but the results were largely negative.

In each case, the "dominant high," or anticyclone, was selected from the map by inspection. Generally one was chosen which was found in some easterly direction from the low center and within approximately 1,000 miles. For experimental purposes, the synoptic situation during the 30-hour forecast period was inspected to find out which high cell had appeared to be most important in the movement of the low, and that high was chosen as the dominant one. It was thought that if the high proved important, the important features might be the direction from the low center to the high center and the direction that the high center was moving at forecast time. (For the latter direction it was generally necessary to measure the direc-

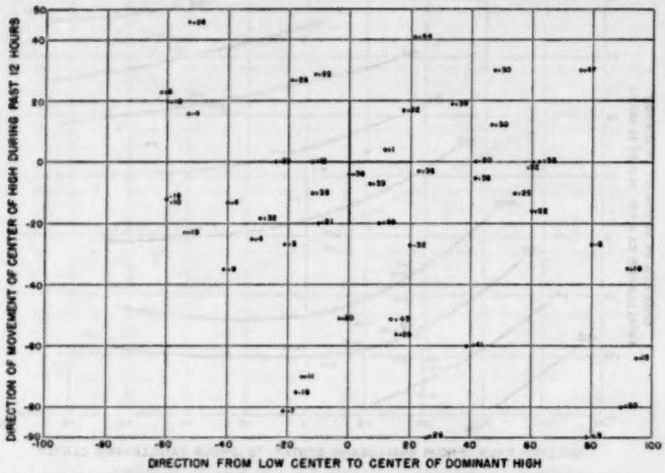

FIGURE 31.—Graph showing relationship of direction low center moved during subsequent 30 hours (values entered beside plotted points) to (a) the direction from the low center to the dominant high, and (b) the direction in which the high center had been moving during the past 12 hours.

tion of movement of the high center over the last 6 or 12 hours.) For example, a low in eastern Kansas might not be expected to move very much north of east during the next 24 to 30 hours if an extensive high cell existed in the vicinity of Winnipeg and were moving more or less southeastward.

Figure 31 shows the direction from the low center to the center of the dominant high plotted against the direction the high center had been moving during the past 12 hours. Data entered beside each point are directions the low centers actually moved during the subsequent 30 hours. The lower right-hand portion of the chart represents the example above, and none of the cases therein actually moved to the north of east-northeast. The upper right-hand portion of figure 31 represents cases in which the high was to the northeast and was moving more or less toward the northeast. In such cases the low tends to follow along behind the high as it moves out. From many aspects this chart appears to be reasonable and to be somewhat in agreement with synoptic experience, but too many cases do not fit. If a logical pattern could be drawn, it would be an extremely complicated one with regions of more or less discontinuity in it.

Charts similar to figure 31 were constructed with the residuals from figures 14, 15, 16, and 17 entered beside each plotted point. For all cases together, no relationship was apparent; but when the cases were stratified according to geographical types, the residuals from forecasts for the Alberta Lows seemed to be systematically distributed. However, when tested on independent data the relationship was almost completely reversed, so the idea of improving the graphical forecasts by using the dominant high was abandoned.

THICKNESS OF THE LAYER FROM 1,000 TO 700 MB.

It has been suggested that cyclones tend to follow closely along the line which represents the thickness of the layer from 1,000 to 700 mb. above the surface low center. A subjective examination of the data indicated that this was generally true, but no lag relationship could be found. To use this parameter, it would be necessary to forecast first the subsequent position of the thickness line in question before it could be applied to forecasting 30-hour direction of movement of cyclones. This appeared to be a problem which was at least as difficult as forecasting the direction of the low center itself; so after a considerable amount of experimenting with some empirical methods of using the thickness chart, that too was abandoned.

24-HOUR HEIGHT CHANGES AT 500 MB.

It has been suggested by Schmidt [8] and by others [9] that surface lows tend to move in 24 hours into the region currently occupied by the positive 24-hour height change area at 500 mb. An investigation of the data disclosed that this rule must often be applied rather subjectively and even then it often fails.

The sample of dependent data which was used throughout this study included only 3 months for which 500-mb., 24-hour height change charts were available; so it was not possible to make exhaustive tests. The rule proved, however, to be correct within 15° in 8 of the 15 cases tested. Examination of these 15 cases showed that this 500-mb. indication was usually quite different from the indication obtained from the graphical forecast using surface data and that possibly it contained independent information. Figure 32 shows the differences between the graphical forecast and the observed 30-hour directions plotted against the differences between the graphical forecasts and the directions to the 24-hour positive height change area at 500 mb. Apparently a relationship exists between these parameters which could be utilized for a slight improvement in graphical forecasts. However, in 9 out of 10 independent cases used in testing, an exactly opposite relationship was suggested; therefore, it was concluded that both original and test samples were too small and it is very likely that no relationship exists.

GEOGRAPHICAL DISTRIBUTION OF RESIDUALS

It would seem that perhaps this graphical procedure which considers all cases more or less regardless of geographical type and location would tend to produce errors of a certain sign in certain areas. Therefore, figure 33 was prepared to show each case plotted at the position where the surface low center existed at the time the forecast was made. Beside each point the residual from forecasts made from figures 14, 15, 16, and 17 was entered. (Positive values indicate that the isopleths on the charts forecast a direction which was to the north of the observed direction.) Although isograms were drawn on figure 33,

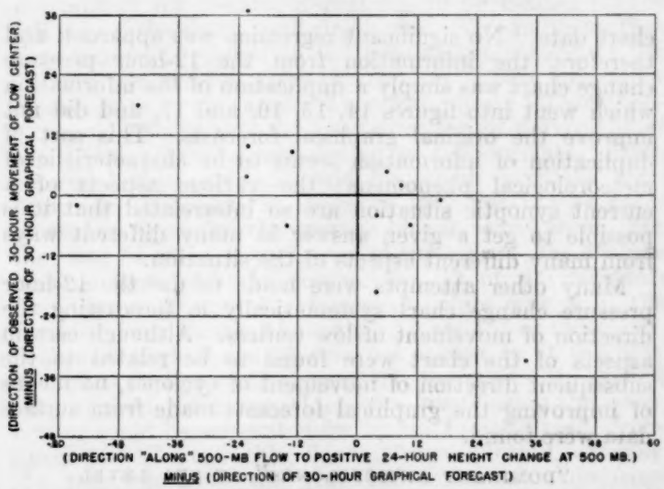
(DIRECTION OF OBSERVED 30-HOUR MOVEMENT OF LOW CENTER)
MINUS (DIRECTION OF 30-HOUR GRAPHICAL FORECAST)
(DIRECTION "ALONG" 500-MB FLOW TO POSITIVE 24-HOUR HEIGHT CHANGE AT 500 MB.)
MINUS (DIRECTION OF 30-HOUR GRAPHICAL FORECAST)

FIGURE 32.—Graph showing differences between the graphical forecasts and the observed directions of movement of the low centers plotted against the differences between the graphical forecasts and the direction to the 24-hour positive height change area at 500 mb.

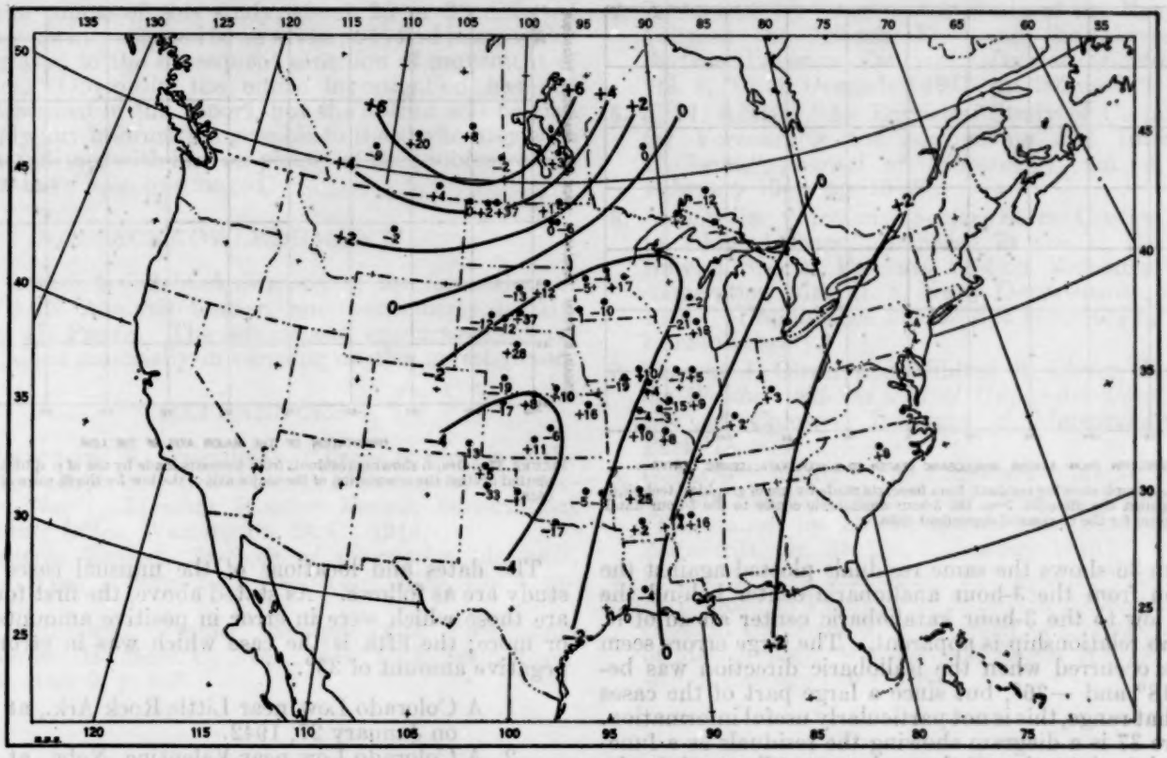

FIGURE 33.—Map showing a plot of each of the 68 cases of dependent data in its geographical location at the time the forecast was made. Isopleths are drawn from values entered beside each point which represent residuals from forecasts made from figures 14 through 17.

there was considerable doubt as to their validity. When the chart was used to determine "expected error" for 27 independent cases, 10 cases were improved, 11 cases were made worse, and 6 cases were not changed. This suggested that no conclusions can be drawn as to the probable amount and sign of the forecasting error due simply to the location of the low in question.

RESIDUALS AND THE SIGNIFICANT VARIABLES

In order to determine whether or not each of the four variables in figures 14, 15, 16, and 17 was used as well as was practicable, the residuals from these charts were plotted against each of the four variables separately. Figure 34 shows the residuals from the 68 cases of dependent data plotted against the direction the surface low center had moved during the past 6 hours. No significant regression is apparent, but it should be noted that all errors of 20° or more occurred when the direction of movement during the past 6 hours had been toward the east or to the south of east, even though the majority of such cases were forecast correctly to within about 12°. In using the system, therefore, the forecaster should be particularly careful when making forecasts for lows which have not recurved.

Figure 35 shows the residuals from the same 68 cases plotted against the normal direction. No relationship is apparent, but it can be seen that the large errors occurred with cases having negative normals. Nearly all cases to the left of the vertical zero line on Figure 35 are cases of Alberta Lows, and although most are forecast fairly well, some are complete "busts."

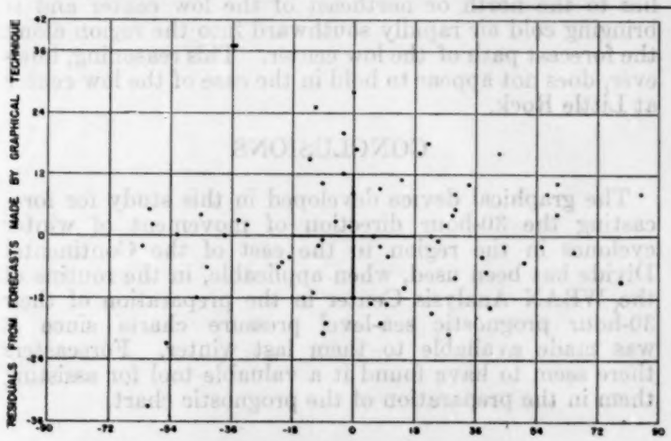

FIGURE 34.—Graph showing residuals from forecasts made by use of graphical technique plotted against the direction the surface low center had moved during the past 6 hours for the 68 cases of dependent data.

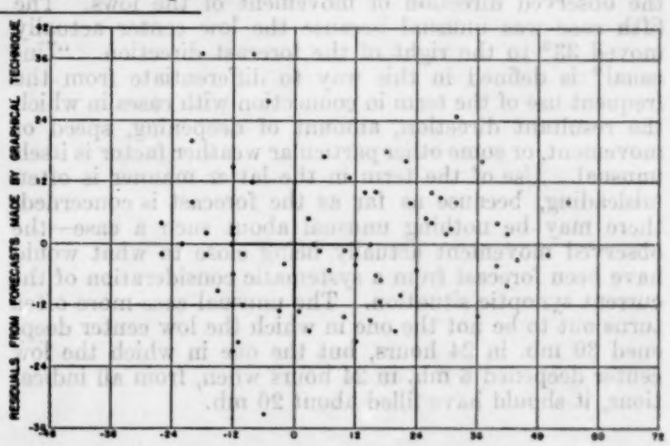

FIGURE 35.—Graph showing residuals from forecasts made by use of graphical technique plotted against the direction of normal 24-hour movement of low centers for 68 cases of dependent data.

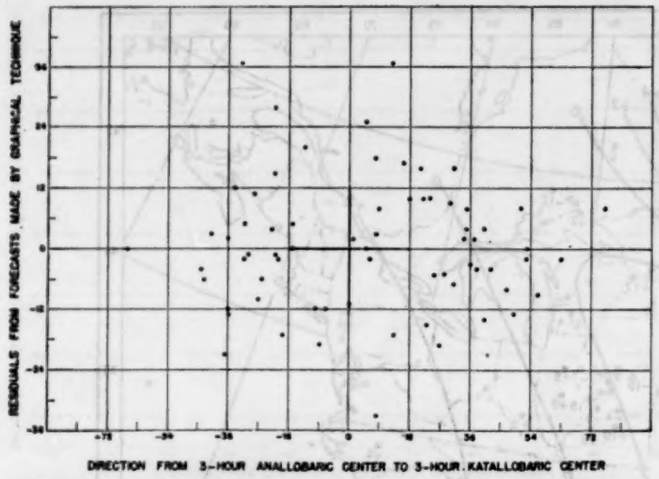
RESIDUALS FROM FORECASTS MADE BY GRAPHICAL TECHNIQUE
DIRECTION FROM 3-HOUR ANALLOBARIC CENTER TO 3-HOUR KATALLOBARIC CENTER

FIGURE 36.—Graph showing residuals from forecasts made by use of graphical technique plotted against the direction from the 3-hour anallobaric center to the 3-hour katallobaric center for the 68 cases of dependent data.

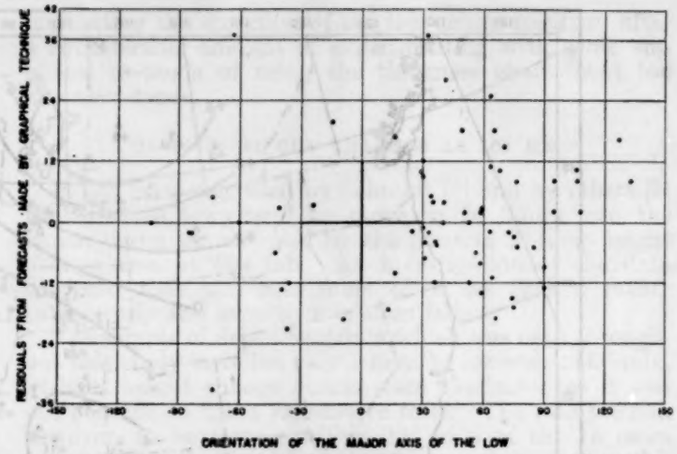

FIGURE 37.—Graph showing residuals from forecasts made by use of graphical technique plotted against the orientation of the major axis of the low for the 68 cases of dependent data.

Figure 36 shows the same residuals plotted against the direction from the 3-hour anallobaric center behind the surface low to the 3-hour katallobaric center ahead of it. Again no relationship is apparent. The large errors seem to have occurred when the isallobaric direction was between 18° and −36°, but since a large part of the cases lies in that range, this is not particularly useful information.

Figure 37 is a diagram showing the residuals as a function of the orientation of the major over-all trough in the sea-level pressure pattern. No relationship exists, and little, if anything, can be said as to the likelihood of occurrence of large errors with any particular range of values of trough direction.

In conclusion, it may be said that the four surface factors which were used to construct figures 14, 15, 16, and 17 were used in such a way that additional information cannot be readily obtained from them.

SUGGESTIONS

This study has brought to light five "unusual" cases, for which complete case studies should be made. Four of them were unusual inasmuch as the forecast results prepared by the system comprised in figures 14, 15, 16, and 17 were in error in positive amounts of 25° or more—that is, the direction forecast was more than 24° to the left of the observed direction of movement of the lows. The fifth case was unusual because the low center actually moved 33° to the right of the forecast direction. "Unusual" is defined in this way to differentiate from the frequent use of the term in connection with cases in which the resultant direction, amount of deepening, speed of movement, or some other particular weather factor is itself unusual. Use of the term in the latter manner is often misleading, because as far as the forecast is concerned, there may be nothing unusual about such a case—the observed movement actually being close to what would have been forecast from a systematic consideration of the current synoptic situation. The unusual case more often turns out to be not the one in which the low center deepened 30 mb. in 24 hours, but the one in which the low center deepened 6 mb. in 24 hours when, from all indications, it should have filled about 20 mb.

The dates and locations of the unusual cases in this study are as follows. As stated above, the first four cases are those which were in error in positive amounts of 25° or more; the fifth is the case which was in error in the negative amount of 33°.

1. A Colorado Low near Little Rock Ark., at 0030 Z. on January 27, 1942.
2. A Colorado Low near Valentine, Nebr., at 0630 Z. on January 6, 1943.
3. An Alberta Low near Valentine, Nebr., at 1830 Z. on January 15, 1943.
4. An Alberta Low near Williston, N. Dak., at 0630 Z. on January 13, 1945.
5. A Northern Rocky Mountain Low near Amarillo, Tex., at 0630 Z. on December 24, 1945.

Presumably the clue to the correct forecast in these five cases does not lie in such simple things as a steering current or a map of sea-level pressure changes. The answer may not be on any of the synoptic charts at all, but, on the other hand, it probably is. Some of the unpublished aspects of this study suggest that the answer lies somewhere in the temperature field.

From an insufficient study of these five cases, it appears that the forecast is likely to be for movement too far to the left when an extensive high pressure area at sea level lies to the north or northeast of the low center and is bringing cold air rapidly southward into the region along the forecast path of the low center. This reasoning, however, does not appear to hold in the case of the low center at Little Rock.

CONCLUSIONS

The graphical device developed in this study for forecasting the 30-hour direction of movement of winter cyclones in the region to the east of the Continental Divide has been used, when applicable, in the routine of the WBAN Analysis Center in the preparation of their 30-hour prognostic sea-level pressure charts since it was made available to them last winter. Forecasters there seem to have found it a valuable tool for assisting them in the preparation of the prognostic chart.

In the course of this study, about 25 or 30 different factors were investigated in an attempt to find items which were related to the subsequent direction of movement of cyclones. Obviously the entire investigation has not been described in this report, but the author will be glad to supply any information possible to those who may wish to communicate with him on phases of the problem which seem to have been overlooked.

ACKNOWLEDGMENT

The author is indebted to many of the forecasters of the WBAN Analysis Center, and particularly to Mr. Charles H. Pierce. The advice and encouragement received aided materially in carrying on this investigation.

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METEOROLOGICAL AND CLIMATOLOGICAL DATA FOR SEPTEMBER 1948

AEROLOGICAL OBSERVATIONS

[For description of change in Table 1 and charts, see REVIEW, January 1946, p. 6]

TABLE 1.—*Mean dynamic height (geopotential) in units of 0.98 dynamic meters, temperature in degrees centigrade, and relative humidity in percent, for standard pressures, as obtained by radiosondes during September 1948*

STATIONS AND MEAN SURFACE PRESSURES

Standard pressure surface (mb.)	Albany, N. Y. (1,007.5 mb.)				Albuquerque, N. Mex. (838.7 mb.)				Atlanta, Ga. (981.9 mb.)				Big Spring, Tex. (927.0 mb.)				Bismarck, N. Dak. (954.9 mb.)				Boise, Idaho (914.3 mb.)				Brownsville, Tex. (1,011.2 mb.)			
	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity
Surface	30	86	14.5	80	30	1,620	23.3	32	30	300	20.8	77	30	774	24.3	44	30	505	18.2	49	30	868	18.0	45	30	6	25.2	84
1,000	30	149	16.8	73	30	50	(*)	----	30	141	(*)	----	30	101	(*)	----	30	104	(*)	----	30	90	(*)	----	30	104	25.5	80
950	30	503	15.9	60	30	514	(*)	----	30	590	21.3	65	30	559	(*)	----	30	550	(*)	----	30	541	(*)	----	30	556	23.3	73
900	30	1,044	12.8	61	30	997	(*)	----	30	1,054	18.6	67	30	1,033	24.3	43	30	1,014	19.1	40	30	1,003	20.3	34	30	1,027	20.9	64
850	30	1,522	9.6	63	30	1,502	(*)	----	30	1,542	15.3	67	30	1,530	20.4	46	30	1,503	16.7	43	30	1,494	17.9	30	30	1,520	18.0	64
800	30	2,022	6.4	63	30	2,030	21.8	30	30	2,054	12.1	64	30	2,050	16.3	50	30	2,016	13.3	46	30	2,009	14.1	32	30	2,037	15.1	62
750	30	2,555	3.9	52	30	2,589	17.3	35	30	2,595	9.1	53	30	2,601	12.6	46	30	2,560	10.0	43	30	2,551	9.8	34	30	2,584	12.4	54
700	30	3,108	1.6	42	30	3,170	12.4	41	30	3,161	6.6	43	30	3,171	9.2	40	30	3,125	6.3	43	30	3,117	5.5	38	30	3,158	9.7	47
650	30	3,707	−1.5	37	30	3,790	7.4	46	30	3,771	3.7	33	30	3,791	5.6	35	30	3,730	2.1	44	30	3,722	.9	41	30	3,771	6.3	45
600	30	4,336	−5.1	36	30	4,439	2.0	50	30	4,412	.3	----	30	4,428	1.3	34	30	4,370	−2.4	45	30	4,356	−3.6	43	30	4,422	2.7	44
550	30	5,016	−8.9	28	30	5,133	−3.4	52	30	5,107	−3.3	----	30	5,129	−3.0	----	30	5,055	−7.0	42	30	5,040	−8.1	37	30	5,119	−1.0	42
500	30	5,746	−13.7	33	30	5,881	−8.6	45	30	5,853	−7.4	----	30	5,874	−7.7	----	29	5,795	−12.1	43	30	5,771	−13.0	38	30	5,876	−5.4	38
450	30	6,545	−19.2	34	30	6,698	−13.8	43	30	6,672	−12.5	----	30	6,694	−12.9	----	27	6,606	−17.5	44	30	6,570	−18.1	----	30	6,700	−10.5	35
400	30	7,405	−25.7	----	30	7,575	−19.6	----	30	7,556	−18.5	----	30	7,580	−18.9	----	27	7,470	−23.8	----	30	7,436	−24.4	----	30	7,591	−16.5	----
350	30	8,358	−32.7	----	29	8,552	−26.9	----	30	8,537	−25.9	----	29	8,559	−25.9	----	26	8,431	−30.8	----	30	8,394	−31.8	----	29	8,581	−23.4	----
300	29	9,426	−40.3	----	29	9,644	−35.5	----	29	9,639	−33.8	----	29	9,658	−34.0	----	25	9,506	−39.2	----	30	9,464	−40.0	----	28	9,691	−31.2	----
250	29	10,647	−48.4	----	29	10,887	−44.9	----	29	10,892	−42.8	----	29	10,910	−43.2	----	24	10,736	−47.9	----	30	10,685	−48.5	----	27	10,956	−40.3	----
200	29	12,090	−55.7	----	29	12,349	−53.7	----	29	12,363	−52.9	----	29	12,381	−52.8	----	24	12,181	−55.4	----	28	12,136	−55.5	----	27	12,438	−52.2	----
175	29	12,935	−58.4	----	29	13,198	−58.2	----	29	13,213	−58.2	----	29	13,231	−58.3	----	23	13,021	−58.2	----	28	12,982	−57.5	----	27	13,285	−58.7	----
150	29	13,900	−59.7	----	28	14,162	−62.9	----	29	14,171	−63.5	----	29	14,189	−63.3	----	22	13,991	−59.9	----	26	13,953	−59.1	----	27	14,240	−65.5	----
125	26	15,030	−60.9	----	25	15,270	−66.7	----	26	15,278	−67.6	----	26	15,297	−68.2	----	14	15,097	−60.4	----	24	15,093	−60.3	----	26	15,329	−72.0	----
100	21	16,407	−60.1	----	17	16,612	−68.6	----	13	16,605	−68.8	----	10	16,570	−71.5	----	6	16,470	−57.7	----	16	16,510	−62.5	----	20	16,621	−74.5	----
80	18	17,804	−59.4	----	8	17,948	−66.2	----	5	17,939	−65.8	----									8	17,886	−59.7	----	14	17,925	−71.2	----
60	12	19,616	−57.2	----																	5	19,688	−58.0	----	6	19,665	−62.9	----
50	7	20,767	−56.0	----																								

Standard pressure surface (mb.)	Buffalo, N. Y. (992.5 mb.)				Camaguey, Cuba (1,000.2 mb.)				Caribou, Maine (993.1 mb.)				Charleston, S. C. (1,014.5 mb.)				Ciudad Victoria, Mexico (972.0 mb.)				Columbia, Mo. (988.5 mb.)				Dodge City, Kans. (925.4 mb.)			
	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity
Surface	30	221	16.2	75	23	122	24.0	92	30	191	10.7	86	30	13	21.2	90	27	335	27.5	61	30	239	20.1	71	30	792	21.5	52
1,000	30	155	(*)	----	23	124	24.0	92	30	131	(*)	----	30	138	22.4	83	27	81	(*)	----	30	138	(*)	----	30	109	(*)	----
950	30	600	16.7	61	23	578	23.3	87	30	567	12.8	55	30	589	20.7	76	27	537	20.2	61	30	588	21.3	58	30	566	(*)	----
900	30	1,053	13.9	60	23	1,047	21.0	80	30	1,015	9.9	64	30	1,051	17.9	74	27	1,011	22.3	65	30	1,050	18.1	58	30	1,034	22.5	46
850	30	1,533	10.7	60	23	1,540	17.9	76	30	1,487	6.7	68	30	1,539	15.4	68	27	1,506	18.3	71	30	1,537	15.0	58	30	1,529	19.8	46
800	30	2,035	7.9	56	23	2,058	14.8	73	30	1,983	3.7	66	30	2,052	13.0	61	27	2,023	14.4	77	30	2,048	12.4	49	30	2,049	16.8	43
750	30	2,571	5.4	49	23	2,603	11.7	66	30	2,509	1.6	58	30	2,597	10.2	57	27	2,569	10.9	76	30	2,595	9.3	50	30	2,600	13.3	40
700	30	3,126	2.5	48	23	3,177	8.5	61	30	3,058	−.6	44	30	3,164	7.2	51	27	3,141	8.0	70	30	3,156	6.3	44	30	3,173	9.4	40
650	29	3,723	−.4	44	23	3,787	5.0	64	30	3,650	−3.6	42	30	3,776	3.7	47	26	3,753	5.1	61	30	3,763	2.8	38	30	3,786	5.1	39
600	29	4,356	−4.1	41	23	4,436	1.3	64	30	4,276	−7.3	41	30	4,416	.1	48	26	4,400	1.7	59	30	4,404	−.8	34	30	4,430	.6	33
550	29	5,040	−8.3	38	22	5,133	−2.7	61	30	4,947	−11.4	43	30	5,112	−3.5	50	25	5,104	−1.7	----	30	5,097	−5.1	37	30	5,122	−3.9	----
500	29	5,771	−13.2	----	22	5,881	−7.0	60	30	5,672	−16.4	45	30	5,857	−7.5	44	25	5,855	−6.2	----	30	5,836	−9.8	34	30	5,867	−9.0	----
450	29	6,573	−18.9	----	21	6,709	−11.8	59	30	6,458	−21.8	----	28	6,678	−12.6	----	24	6,685	−11.2	----	30	6,651	−15.2	----	30	6,681	−14.3	----
400	29	7,432	−25.1	----	20	7,586	−17.4	65	30	7,313	−28.0	----	28	7,558	−18.3	----	23	7,569	−16.4	----	30	7,517	−21.6	----	30	7,558	−20.8	----
350	29	8,387	−32.2	----	19	8,573	−24.5	----	30	8,257	−35.1	----	28	8,541	−25.3	----	22	8,559	−23.7	----	30	8,490	−28.8	----	30	8,530	−28.2	----
300	29	9,457	−40.1	----	19	9,678	−32.9	----	30	9,313	−42.4	----	28	9,640	−33.7	----	22	9,668	−31.9	----	29	9,570	−37.2	----	30	9,616	−36.6	----
250	28	10,675	−48.7	----	19	10,932	−43.4	----	30	10,525	−49.2	----	28	10,893	−43.4	----	22	10,931	−42.0	----	28	10,803	−46.4	----	30	10,854	−45.7	----
200	27	12,111	−55.7	----	17	12,441	−56.2	----	23	11,986	−53.9	----	28	12,359	−54.1	----	21	12,403	−54.3	----	28	12,256	−54.5	----	30	12,308	−54.8	----
175	21	12,947	−57.5	----	17	13,222	−63.3	----	21	12,843	−55.5	----	27	13,204	−59.6	----	15	13,246	−61.3	----	25	13,109	−57.6	----	28	13,157	−58.8	----
150	16	13,925	−59.6	----	15	14,155	−70.3	----	12	13,830	−56.1	----	27	14,155	−65.1	----	13	14,168	−68.7	----	20	14,066	−61.6	----	14	14,127	−63.2	----
125	5	15,126	−61.4	----	7	15,235	−76.4	----					23	15,246	−69.1	----	8	15,224	−74.2	----	11	15,174	−64.6	----				
100													18	16,574	−70.2	----					5	16,504	−65.3	----				
80													11	17,906	−67.4	----												
60													7	19,662	−61.0	----												

Standard pressure surface (mb.)	El Paso, Tex. (881.2 mb.)				Ely, Nev. (809.2 mb.)				Fort Worth, Tex. (989.7 mb.)				Glasgow, Mont. (938.0 mb.)				Grand Junction, Colo. (852.2 mb.)				Great Falls, Mont. (887.1 mb.)				Greensboro, N. C. (987.3 mb.)			
	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity
Surface	30	1,195	25.2	34	30	1,908	16.2	30	30	211	25.4	48	30	648	18.5	38	30	1,474	21.4	32	30	1,128	16.6	37	29	273	18.2	81
1,000	30	65	(*)	----	30	55	(*)	----	30	119	(*)	----	30	90	(*)	----	30	55	(*)	----	30	89	(*)	----	29	161	(*)	----
950	30	533	(*)	----	30	518	(*)	----	30	574	25.3	45	30	543	(*)	----	30	520	(*)	----	30	540	(*)	----	29	605	19.1	68
900	30	1,013	(*)	----	30	991	(*)	----	30	1,045	21.7	49	30	1,003	19.8	33	30	998	(*)	----	30	1,007	(*)	----	29	1,068	16.7	68
850	30	1,512	24.3	33	30	1,483	(*)	----	30	1,538	17.7	55	30	1,492	16.3	36	30	1,496	(*)	----	30	1,491	16.1	34	29	1,553	13.8	71
800	20	2,038	20.3	36	30	2,006	18.7	25	30	2,053	14.1	56	30	2,004	12.6	41	30	2,024	21.4	26	30	2,003	12.2	37	29	2,063	11.1	69
750	30	2,594	15.7	43	30	2,559	15.3	26	30	2,601	11.5	45	30	2,545	8.5	46	30	2,580	16.9	29	30	2,542	8.1	42	29	2,600	8.4	66
700	30	3,171	11.0	48	30	3,135	10.2	30	30	3,169	8.4	38	30	3,108	5.0	44	30	3,161	11.8	34	30	3,104	3.9	46	29	3,167	5.7	56
650	30	3,784	6.2	51	30	3,747	5.0	36	30	3,783	5.0	35	30	3,709	1.2	41	30	3,779	6.5	41	30	3,705	−.4	47	29	3,774	2.8	49
600	30	4,435	1.5	51	30	4,392	−.4	40	30	4,427	1.0	32	30	4,348	−3.4	43	30	4,426	.9	48	30	4,338	−4.5	44	29	4,415	−.9	46
550	30	5,131	−3.3	51	30	5,082	−5.9	48	30	5,123	−3.3	----	30	5,032	−7.8	43	29	5,122	−4.0	43	30	5,017	−9.3	45	29	5,106	−4.7	40
500	29	5,878	−8.1	45	30	5,820	−11.4	49	30	5,869	−8.0	----	29	5,765	−12.8	45	30	5,864	−9.4	44	30	5,754	−14.3	45	29	5,849	−9.1	----
450	29	6,608	−13.4	37	30	6,628	−16.6	----	30	6,691	−13.2	----	29	6,567	−18.5	44	30	6,579	−15.0	----	30	6,546	−19.9	44	28	6,663	−14.6	----
400	28	7,378	−19.4	----	30	7,495	−22.6	----	30	7,566	−19.2	----	29	7,428	−24.8	----	30	7,551	−21.4	----	30	7,402	−26.0	----	27	7,535	−20.6	----
350	28	8,557	−26.8	----	30	8,461	−29.9	----	30	8,545	−26.5	----	29	8,385	−32.0	----	30	8,521	−28.7	----	30	8,353	−33.4	----	27	8,510	−27.1	----
300	28	9,551	−34.7	----	30	9,540	−38.0	----	30	9,639	−34.8	----	27	9,455	−40.0	----	30	9,604	−37.2	----	30	9,417	−41.6	----	27	9,603	−35.0	----
250	26	10,901	−43.5	----	29	10,776	−46.9	----	30	10,886	−43.8	----	26	10,681	−49.0	----	30	10,837	−46.8	----	29	10,628	−50.7	----	27	10,851	−43.8	----
200	26	12,369	−53.2	----	29	12,225	−55.2	----	30	12,352	−53.4	----	25	12,119	−55.5	----	30	12,288	−55.0	----	27	12,063	−55.7	----	27	12,317	−53.8	----
175	25	13,220	−58.8	----	29	13,069	−59.0	----	30	13,200	−58.6	----	19	12,973	−57.3	----	29	13,136	−58.3	----	25	12,906	−57.8	----	27	13,164	−58.7	----
150	25	14,174	−64.5	----	27	14,028	−62.7	----	29	14,154	−64.0	----	18	13,937	−59.2	----	27	14,097	−62.2	----	24	13,877	−58.5	----	25	14,118	−62.9	----
125	24	15,274	−69.7	----	25	15,146	−65.5	----	28	15,258	−68.6	----	18	15,075	−60.2	----	20	15,211	−65.5	----	23	15,017	−59.6	----	19	15,229	−65.3	----
100	10	16,599	−71.2	----	20	16,514	−66.6	----	25	16,578	−70.7	----	18	16,465	−59.7	----	13	16,547	−65.2	----	16	16,406	−59.6	----	9	16,581	−65.4	----
80					14	17,866	−63.8	----	13	17,937	−66.8	----	15	17,859	−58.0	----	6	17,936	−63.5	----	9	17,827	−60.0	----				
60					8	19,665	−60.3	----	8	19,700	−61.0	----	8	19,682	−57.6	----												
50													7	20,837	−57.0	----												

See footnotes at end of table.

TABLE 1.—*Mean dynamic height (geopotential) in units of 0.98 dynamic meters, temperature in degrees centigrade, and relative humidity in percent, for standard pressures, as obtained by radiosondes during September 1948*—Continued

Standard pressure surface (mb.)	Hatteras, N. C. (1,016.8 mb.)				Havana, Cuba [1] (----- mb.)				Honolulu, T. H. (1,013.6 mb.)				International Falls, Minn. (974.7 mb.)				Joliet, Ill. (996.5 mb.)				Lake Charles, La. (1,013.4 mb.)				Lander, Wyo. (829.8 mb.)			
	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity
Surface	30	3	22.6	80	----	----	----	----	30	3	27.9	59	30	360	13.1	80	30	178	16.9	82	30	5	22.8	84	30	1,696	17.3	37
1,000	30	148	22.1	78	----	----	----	----	30	123	25.8	61	30	142	(*)	----	30	148	(*)	----	30	121	23.3	78	30	62	(*)	----
950	30	595	19.4	75	----	----	----	----	30	580	22.0	68	30	585	16.7	59	30	593	19.1	62	30	574	21.4	70	30	523	(*)	----
900	30	1,057	16.7	71	----	----	----	----	30	1,040	18.5	71	30	1,037	15.0	50	30	1,052	16.2	61	30	1,036	18.7	70	30	1,000	(*)	----
850	30	1,542	14.1	63	----	----	----	----	30	1,528	15.4	68	30	1,519	12.2	46	30	1,536	13.5	56	30	1,525	15.6	71	30	1,488	(*)	----
800	30	2,052	11.6	59	----	----	----	----	30	2,040	12.7	60	30	2,025	10.0	38	30	2,044	10.6	55	30	2,038	12.8	64	30	2,010	18.7	31
750	30	2,592	8.9	56	----	----	----	----	30	2,588	11.0	44	30	2,565	7.2	38	30	2,582	7.7	51	30	2,584	9.9	62	30	2,563	14.5	34
700	30	3,158	6.0	53	----	----	----	----	30	3,154	8.4	36	30	3,122	4.3	36	30	3,145	4.5	47	30	3,149	7.2	57	30	3,137	10.0	37
650	30	3,760	2.7	49	----	----	----	----	30	3,769	5.7	31	30	3,723	.7	34	30	3,745	−.8	45	29	3,759	4.2	44	30	3,749	5.2	40
600	30	4,405	−.6	46	----	----	----	----	30	4,415	2.5	----	30	4,359	−3.3	35	30	4,384	−3.1	43	29	4,403	.6	----	30	4,395	−.2	45
550	30	5,095	−4.7	45	----	----	----	----	30	5,113	−1.3	----	30	5,041	−7.9	----	30	5,067	−7.1	43	29	5,100	−3.4	----	30	5,084	−5.6	48
500	30	5,840	−9.0	46	----	----	----	----	30	5,867	−5.9	----	30	5,775	−12.9	----	30	5,804	−11.9	----	29	5,845	−7.8	----	30	5,825	−10.9	45
450	30	6,656	−14.0	46	----	----	----	----	29	6,692	−11.2	----	30	6,577	−18.3	----	30	6,611	−17.2	----	28	6,664	−12.9	----	30	6,635	−16.8	39
400	30	7,533	−19.9	49	----	----	----	----	29	7,580	−17.7	----	30	7,438	−24.6	----	30	7,476	−23.5	----	28	7,543	−19.2	----	30	7,499	−23.3	----
350	29	8,512	−26.9	----	----	----	----	----	28	8,565	−24.8	----	29	8,407	−31.3	----	30	8,438	−30.6	----	28	8,523	−26.0	----	30	8,462	−30.6	----
300	29	9,606	−34.7	----	----	----	----	----	28	9,667	−33.0	----	29	9,479	−39.8	----	29	9,513	−38.4	----	27	9,620	−33.8	----	30	9,537	−39.1	----
250	29	10,853	−44.3	----	----	----	----	----	28	10,924	−42.8	----	29	10,698	−49.5	----	29	10,744	−46.8	----	27	10,874	−42.9	----	30	10,762	−48.0	----
200	29	12,312	−55.1	----	----	----	----	----	28	12,391	−54.0	----	28	12,137	−56.7	----	27	12,193	−55.4	----	27	12,343	−53.9	----	27	12,216	−56.1	----
175	28	13,157	−60.0	----	----	----	----	----	28	13,236	−59.7	----	26	12,964	−58.7	----	27	13,038	−58.3	----	26	13,193	−60.0	----	25	13,060	−58.7	----
150	27	14,109	−64.0	----	----	----	----	----	25	14,195	−64.9	----	24	13,948	−60.0	----	19	13,993	−60.3	----	26	14,141	−66.2	----	15	14,036	−61.7	----
125	12	15,208	−66.9	----	----	----	----	----	25	15,294	−69.2	----	9	15,064	−58.0	----	14	15,088	−62.7	----	23	15,225	−71.8	----	----	----	----	----
100	7	16,569	−66.6	----	----	----	----	----	24	16,617	−71.6	----	5	16,478	−55.8	----	6	16,438	−61.8	----	16	16,531	−73.0	----	----	----	----	----
80	----	----	----	----	----	----	----	----	23	17,938	−68.9	----	----	----	----	----	----	----	----	----	9	17,858	−69.4	----	----	----	----	----
60	----	----	----	----	----	----	----	----	21	19,685	−62.7	----	----	----	----	----	----	----	----	----	5	19,628	−63.1	----	----	----	----	----
50	----	----	----	----	----	----	----	----	21	20,816	−59.6	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
40	----	----	----	----	----	----	----	----	18	22,226	−55.5	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
30	----	----	----	----	----	----	----	----	9	24,090	−51.6	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

Standard pressure surface (mb.)	Las Vegas, Nev. (942.6 mb.)				Little Rock, Ark. (1,006.2 mb.)				Mazatlan, Mexico (1,006.0 mb.)				Medford, Oreg. (967.1 mb.)				Merida, Mexico (1,008.0 mb.)				Miami, Fla. (1,013.3 mb.)				Nantucket, Mass. (1,016.1 mb.)			
	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity
Surface	30	574	28.6	16	30	79	21.4	76	29	14	29.6	75	30	401	18.6	57	30	27	27.3	79	29	4	25.7	88	30	14	15.3	89
1,000	30	40	(*)	----	30	133	22.5	69	29	68	29.0	76	30	110	(*)	----	30	98	26.8	79	29	120	25.5	84	30	150	16.8	76
950	30	506	(*)	----	30	582	22.6	57	29	530	25.3	81	30	558	19.7	47	30	552	24.8	77	29	572	23.0	83	30	590	15.6	63
900	30	986	29.4	----	30	1,049	19.1	61	29	999	22.9	75	30	1,017	16.6	48	30	1,025	21.9	74	29	1,042	20.3	79	30	1,044	13.0	61
850	30	1,491	25.2	20	30	1,537	15.9	62	29	1,496	20.2	71	30	1,501	12.8	52	30	1,520	18.8	76	29	1,534	17.4	75	30	1,523	10.2	59
800	30	2,018	20.5	23	30	2,050	13.1	57	29	2,018	17.4	68	30	2,007	9.3	56	30	2,039	15.5	79	28	2,056	14.5	73	30	2,025	7.6	52
750	30	2,573	15.6	26	30	2,595	10.2	50	29	2,575	14.6	62	30	2,546	6.4	48	30	2,588	13.0	69	28	2,603	11.6	68	30	2,560	5.5	40
700	30	3,149	10.7	29	30	3,161	7.4	42	29	3,148	10.8	61	30	3,101	3.0	43	30	3,163	10.0	61	28	3,174	8.6	63	30	3,116	3.2	34
650	30	3,765	6.0	31	29	3,775	4.2	40	29	3,766	6.6	63	30	3,701	−.3	39	30	3,775	6.5	57	28	3,782	5.0	65	29	3,719	.1	36
600	30	4,411	.9	31	29	4,418	.8	38	29	4,416	2.3	65	30	4,333	−4.2	34	30	4,429	2.9	54	28	4,433	1.3	67	29	4,351	−3.7	37
550	30	5,105	−3.7	----	29	5,113	−3.3	36	29	5,116	−2.0	61	30	5,012	−8.2	36	30	5,127	−1.3	53	28	5,128	−2.3	65	29	5,036	−7.5	----
500	30	5,851	−8.8	----	29	5,859	−8.1	----	29	5,867	−5.9	47	30	5,747	−13.1	38	30	5,882	−5.8	51	26	5,882	−6.2	54	28	5,764	−12.4	----
450	30	6,665	−14.3	----	29	6,673	−13.6	----	29	6,693	−10.7	45	30	6,548	−18.9	39	30	6,706	−10.6	48	26	6,707	−10.9	54	28	6,573	−18.0	----
400	30	7,542	−20.8	----	29	7,554	−19.8	----	29	7,583	−16.1	44	30	7,408	−25.1	----	29	7,598	−15.9	47	26	7,596	−16.5	52	28	7,432	−24.3	----
350	30	8,514	−28.5	----	29	8,530	−27.2	----	28	8,575	−23.2	----	30	8,364	−32.3	----	29	8,589	−23.0	----	26	8,586	−23.4	----	28	8,391	−30.9	----
300	30	9,599	−37.2	----	29	9,621	−35.3	----	28	9,684	−31.6	----	29	9,428	−40.3	----	29	9,698	−31.7	----	26	9,695	−31.6	----	28	9,468	−38.2	----
250	30	10,834	−46.1	----	29	10,868	−43.9	----	27	10,948	−41.7	----	29	10,647	−48.9	----	28	10,900	−42.0	----	25	10,962	−41.4	----	28	10,699	−47.0	----
200	28	12,295	−54.2	----	27	12,333	−52.6	----	17	12,434	−53.4	----	29	12,084	−55.7	----	28	12,429	−54.9	----	25	12,437	−53.5	----	28	12,148	−55.2	----
175	25	13,156	−58.6	----	27	13,186	−57.3	----	6	13,276	−60.4	----	28	12,927	−57.8	----	28	13,267	−62.2	----	25	13,282	−60.0	----	28	12,994	−57.8	----
150	20	14,106	−62.7	----	27	14,147	−62.6	----	----	----	----	----	28	13,894	−59.2	----	28	14,201	−69.8	----	22	14,232	−66.9	----	28	13,962	−59.1	----
125	12	15,203	−66.7	----	23	15,266	−66.8	----	----	----	----	----	26	15,031	−60.6	----	22	15,266	−76.8	----	14	15,319	−73.1	----	28	15,099	−60.8	----
100	----	----	----	----	15	16,606	−68.4	----	----	----	----	----	23	16,412	−61.1	----	8	16,560	−79.8	----	10	16,619	−75.3	----	24	16,478	−60.4	----
80	----	----	----	----	----	----	----	----	----	----	----	----	12	17,812	−59.6	----	----	----	----	----	----	----	----	----	15	17,864	−59.0	----
60	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	10	19,662	−56.4	----
50	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	5	20,822	−55.4	----

Standard pressure surface (mb.)	Nashville, Tenn. (995.9 mb.)				New Orleans, La. (1,013.4 mb.)				North Platte, Nebr. (917.9 mb.)				Oakland, Calif. (1,012.2 mb.)				Oklahoma City, Okla. (969.8 mb.)				Omaha, Nebr. (980.2 mb.)				Phoenix, Ariz. (968.6 mb.)			
	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity
Surface	30	177	21.3	69	29	2	23.3	83	30	849	18.6	64	30	6	16.2	76	30	391	23.1	51	28	308	21.1	70	30	339	29.9	32
1,000	30	141	(*)	----	29	118	23.5	79	30	101	(*)	----	30	109	15.7	75	30	119	(*)	----	28	134	(*)	----	30	51	(*)	----
950	30	590	20.8	57	29	569	21.5	74	30	554	(*)	----	30	556	19.2	48	30	574	24.8	43	28	582	21.8	55	30	520	33.4	22
900	30	1,052	17.5	61	29	1,034	18.6	75	30	1,019	21.6	50	30	1,012	19.1	34	30	1,044	21.9	45	28	1,047	18.8	56	30	998	29.5	23
850	30	1,538	14.0	65	29	1,523	15.7	70	30	1,513	18.9	46	30	1,501	16.9	32	30	1,537	18.2	48	28	1,535	15.7	54	30	1,503	25.4	27
800	30	2,047	10.8	61	29	2,036	13.1	62	30	2,031	15.9	46	30	2,015	14.4	26	30	2,054	15.3	42	28	2,048	13.7	44	30	2,030	20.7	32
750	30	2,589	8.3	52	29	2,582	10.4	58	30	2,581	12.6	43	30	2,562	11.2	----	30	2,601	12.2	40	28	2,594	10.6	41	30	2,586	16.0	37
700	30	3,151	5.5	44	29	3,149	7.8	50	30	3,152	8.6	42	30	3,128	7.5	----	30	3,172	9.1	34	28	3,160	7.0	38	30	3,165	11.4	37
650	30	3,759	2.3	42	29	3,758	4.6	45	30	3,762	4.2	42	30	3,738	3.8	----	30	3,782	5.5	33	28	3,768	3.0	37	30	3,782	6.9	36
600	29	4,398	−.9	36	28	4,406	1.1	43	30	4,406	−.5	39	30	4,350	−.4	----	30	4,430	1.2	33	28	4,408	−1.3	37	30	4,431	2.0	37
550	29	5,091	−4.7	----	28	5,104	−2.6	40	29	5,095	−5.3	36	30	5,071	−4.8	----	30	5,123	−3.2	29	28	5,100	−5.6	----	30	5,127	−3.2	38
500	28	5,832	−9.3	----	27	5,851	−7.0	----	29	5,836	−10.5	----	30	5,813	−9.6	----	30	5,872	−8.1	30	28	5,837	−10.2	----	29	5,873	−8.5	34
450	28	6,650	−14.8	----	27	6,676	−11.8	----	29	6,647	−15.8	----	30	6,625	−15.5	----	29	6,688	−13.8	----	28	6,646	−15.6	----	26	6,699	−13.8	----
400	28	7,521	−21.1	----	27	7,559	−17.6	----	29	7,517	−22.5	----	30	7,498	−21.6	----	29	7,564	−20.4	----	28	7,519	−22.0	----	26	7,571	−20.0	----
350	28	8,497	−28.0	----	26	8,544	−24.6	----	29	8,483	−29.9	----	30	8,468	−28.8	----	29	8,540	−27.2	----	28	8,486	−29.5	----	26	8,547	−27.4	----
300	26	9,592	−35.4	----	26	9,648	−32.5	----	29	9,563	−38.3	----	30	9,552	−37.1	----	29	9,632	−35.3	----	28	9,568	−37.8	----	26	9,639	−35.8	----
250	25	10,836	−46.1	----	25	10,909	−41.7	----	29	10,792	−46.1	----	29	10,790	−46.0	----	28	10,878	−43.9	----	28	10,799	−47.4	----	26	10,883	−44.5	----
200	25	12,303	−53.2	----	23	12,393	−53.1	----	29	12,234	−56.3	----	29	12,246	−53.9	----	25	12,343	−53.1	----	27	12,238	−56.2	----	25	12,348	−53.9	----
175	23	13,160	−57.8	----	22	13,245	−59.0	----	27	13,066	−60.2	----	29	13,095	−57.6	----	25	13,193	−57.8	----	25	13,081	−59.3	----	21	13,193	−58.2	----
150	23	14,120	−62.5	----	22	14,198	−64.8	----	15	14,036	−63.3	----	28	14,058	−60.9	----	24	14,154	−62.4	----	14	14,023	−62.2	----	10	14,141	−62.1	----
125	16	15,225	−66.1	----	18	15,283	−69.7	----	6	15,112	−64.6	----	25	15,192	−64.2	----	20	15,265	−66.1	----	10	15,176	−65.7	----	----	----	----	----
100	11	16,559	−66.6	----	7	16,604	−72.8	----	----	----	----	----	19	16,533	−65.0	----	10	16,624	−65.9	----	8	16,521	−66.9	----	----	----	----	----
80	7	17,905	−63.8	----	----	----	----	----	----	----	----	----	7	17,853	−61.1	----	----	----	----	----	7	17,870	−64.0	----	----	----	----	----
60	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	6	19,636	−60.4	----	----	----	----	----

See footnotes at end of table.

TABLE 1.—*Mean dynamic height (geopotential) in units of 0.98 dynamic meters, temperature in degrees centigrade, and relative humidity in percent, for standard pressures, as obtained by radiosondes during September 1948*—Continued

Standard pressure surface (mb.)	Pittsburgh, Pa. (974.0 mb.)				Portland, Maine (1,014.5 mb.)				Rapid City, S. Dak. (903.0 mb.)				St. Cloud, Minn. (979.2 mb.)				San Antonio, Tex. (985.6 mb.)				San Juan, P. R. (1,012.5 mb.)				Santa Maria, Calif. (1,003.9 mb.)			
	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity
Surface	30	382	17.9	67	30	20	13.5	79	29	980	17.5	50	30	317	16.5	74	30	240	24.2	71	30	15	26.5	83	30	71	14.9	80
1,000	30	154	(*)	----	30	142	16.4	69	29	88	(*)	----	30	135	(*)	----	30	111	(*)	----	30	125	25.9	82	30	104	14.8	79
950	30	602	18.0	62	30	581	15.4	59	29	543	(*)	----	30	585	20.0	52	30	567	24.6	59	30	583	23.2	80	30	548	19.1	56
900	30	1,058	15.9	57	30	1,035	12.4	62	29	1,009	(*)	----	30	1,041	17.0	53	30	1,036	21.4	61	30	1,048	20.3	77	30	1,009	21.5	32
850	30	1,541	12.9	60	30	1,512	8.8	65	29	1,502	19.8	37	30	1,526	14.3	48	30	1,529	17.9	65	30	1,540	17.3	74	30	1,501	19.8	27
800	29	2,046	10.1	56	30	2,012	6.0	62	29	2,021	16.4	38	30	2,036	12.1	43	30	2,045	14.4	67	30	2,057	15.0	64	30	2,018	16.0	25
750	29	2,588	7.1	59	30	2,541	3.6	50	29	2,569	12.9	40	30	2,578	9.3	45	30	2,594	11.6	61	30	2,605	12.5	55	30	2,565	12.6	----
700	28	3,145	4.3	54	30	3,095	.6	44	29	3,141	9.0	37	30	3,143	6.0	43	30	3,163	9.0	45	30	3,178	9.5	52	30	3,138	9.2	----
650	28	3,749	1.1	47	30	3,687	−2.4	40	29	3,752	4.5	37	30	3,750	2.3	40	30	3,779	5.8	40	30	3,793	5.8	51	30	3,749	5.2	----
600	28	4,385	−2.6	46	30	4,319	−5.8	36	29	4,396	−.5	42	30	4,388	−1.6	38	30	4,424	1.8	40	30	4,441	2.0	49	30	4,396	1.4	----
550	28	5,071	−6.6	46	30	4,995	− 9.7	38	29	5,086	−5.5	44	30	5,074	−6.2	38	30	5,123	−2.1	38	30	5,140	−2.0	46	30	5,096	−2.6	----
500	28	5,808	−11.1	41	30	5,725	−14.4	----	29	5,826	−10.6	39	30	5,814	−11.2	40	30	5,871	−6.5	----	30	5,890	−6.5	47	30	5,840	−7.2	----
450	28	6,619	−16.5	----	30	6,519	−20.1	----	29	6,634	−16.1	38	30	6,622	−16.4	----	30	6,695	−11.7	----	29	6,717	−11.7	42	30	6,662	−12.9	----
400	27	7,493	−22.4	----	30	7,379	−26.3	----	29	7,505	−22.4	----	30	7,492	−22.5	----	30	7,579	−17.6	----	28	7,599	−17.5	39	29	7,541	−19.7	----
350	26	8,467	−29.1	----	30	8,331	−33.2	----	29	8,471	−29.8	----	30	8,457	−30.0	----	30	8,564	−24.8	----	28	8,585	−24.4	----	29	8,518	−27.1	----
300	26	9,549	−37.2	----	30	9,397	−40.8	----	29	9,551	−38.2	----	30	9,536	−38.4	----	30	9,666	−33.0	----	28	9,689	−33.0	----	29	9,609	−35.6	----
250	26	10,785	−46.2	----	30	10,615	−48.9	----	29	10,780	−47.5	----	30	10,765	−47.5	----	30	10,925	−41.6	----	28	10,945	−43.2	----	29	10,853	−44.3	----
200	25	12,245	−54.5	----	30	12,056	−55.6	----	29	12,226	−55.4	----	30	12,211	−55.6	----	30	12,404	−52.2	----	28	12,408	−55.1	----	28	12,317	−53.0	----
175	25	13,093	−57.8	----	30	12,902	−57.3	----	29	13,071	−57.9	----	30	13,057	−57.5	----	30	13,255	−58.0	----	26	13,248	−61.2	----	27	13,167	−57.6	----
150	25	14,058	−60.2	----	29	13,874	−58.4	----	29	14,036	−60.6	----	28	14,023	−59.3	----	28	14,217	−63.9	----	26	14,190	−67.5	----	25	14,134	−62.6	----
125	22	15,181	−62.3	----	26	15,008	−60.1	----	26	15,159	−62.3	----	21	15,154	−60.2	----	23	15,315	−68.6	----	25	15,272	−72.9	----	23	15,249	−67.1	----
100	11	16,545	−61.7	----	26	16,398	−59.7	----	14	16,523	−61.1	----	11	16,539	−56.5	----	14	16,639	−70.6	----	13	16,567	−74.0	----	16	16,591	−68.0	----
80	7	17,922	−60.7	----	24	17,789	−58.5	----	9	17,901	−58.6	----	8	17,944	−56.4	----	----	----	----	----	----	----	----	----	7	17,967	−66.0	----
60	5	19,720	−58.2	----	21	19,605	−56.3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
50	----	----	----	----	14	20,766	−55.7	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
40	----	----	----	----	8	22,201	−54.3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

Standard pressure surface (mb.)	Sault Ste. Marie, Mich. (992.2 mb.)				Spokane, Wash. (931.3 mb.)				Swan Island, W. I. (1,010.1 mb.)				Tacubaya, Mexico (773.3 mb.)				Tampa, Fla. (1,012.9 mb.)				Tatoosh Island, Wash. (1,012.2 mb.)				Toledo, Ohio (995.1 mb.)			
	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity	Number of observations	Dynamic height	Temperature	Relative humidity
Surface	30	221	10.2	87	30	721	15.8	49	30	10	27.7	80	29	2,306	16.5	71	30	9	24.8	86	30	31	12.9	89	30	191	17.5	77
1,000	30	154	(*)	----	30	110	(*)	----	30	99	27.3	79	29	56	(*)	----	30	121	24.5	84	30	133	12.7	85	30	148	(*)	----
950	30	596	15.3	64	30	552	(*)	----	30	562	23.9	81	29	517	(*)	----	30	577	22.1	82	30	569	12.1	72	30	590	18.7	57
900	30	1,046	13.3	57	30	1,012	16.0	45	30	1,025	21.3	75	29	994	(*)	----	30	1,040	19.5	78	30	1,016	10.0	67	30	1,052	15.8	59
850	30	1,525	10.7	52	30	1,494	12.2	48	30	1,519	18.7	67	29	1,489	(*)	----	30	1,531	16.5	77	30	1,488	7.2	66	30	1,535	12.5	55
800	30	2,028	8.1	51	30	1,999	8.2	51	30	2,038	16.1	57	29	2,015	(*)	----	30	2,046	13.5	71	30	1,985	4.7	61	30	2,041	10.0	55
750	30	2,565	5.5	45	30	2,534	4.5	50	30	2,596	13.0	53	29	2,567	14.3	74	29	2,590	10.7	61	30	2,515	2.3	51	30	2,580	7.0	55
700	30	3,120	2.8	42	30	3,088	1.2	48	30	3,161	9.8	49	29	3,146	9.8	81	29	3,160	7.6	59	30	3,064	−.4	47	30	3,140	4.3	48
650	30	3,720	−.4	39	30	3,682	−2.6	44	30	3,783	6.0	49	29	3,762	5.3	87	29	3,770	4.1	59	30	3,656	−3.9	46	30	3,742	1.0	40
600	30	4,352	−4.1	40	29	4,312	−6.5	44	30	4,424	1.9	53	29	4,409	1.3	89	29	4,414	.5	57	30	4,280	−7.5	45	30	4,380	−2.8	39
550	30	5,035	−8.5	38	29	4,988	−10.7	42	30	5,130	−1.9	50	29	5,108	−2.8	91	29	5,107	−3.3	58	30	4,954	−11.6	40	30	5,064	−7.0	----
500	29	5,772	−13.1	34	29	5,713	−15.3	44	30	5,874	−6.3	52	29	5,857	−6.7	76	29	5,856	−7.2	55	30	5,678	−16.0	40	30	5,801	−11.7	----
450	29	6,576	−18.9	35	29	6,509	−20.6	----	30	6,712	−10.9	46	29	6,685	−11.1	64	29	6,677	−12.0	55	30	6,472	−21.3	----	30	6,610	−17.2	----
400	29	7,435	−25.2	----	29	7,362	−27.0	----	30	7,589	−16.2	42	29	7,571	−16.6	56	29	7,563	−17.5	55	30	7,323	−27.5	----	30	7,473	−23.6	----
350	29	8,390	−32.6	----	28	8,312	−34.1	----	30	8,580	−23.0	----	29	8,560	−23.7	----	29	8,549	−24.3	----	30	8,270	−34.4	----	29	8,440	−30.6	----
300	29	9,458	−40.6	----	27	9,375	−41.7	----	30	9,689	−31.5	----	29	9,667	−32.2	----	29	9,653	−32.6	----	29	9,331	−41.8	----	29	9,517	−38.6	----
250	28	10,673	−49.0	----	26	10,582	−49.5	----	30	10,952	−41.5	----	29	10,926	−42.5	----	29	10,910	−42.6	----	27	10,550	−48.4	----	28	10,748	−47.4	----
200	24	12,119	−55.5	----	24	12,028	−54.7	----	30	12,425	−54.0	----	23	12,392	−55.5	----	28	12,375	−54.9	----	27	11,996	−54.2	----	27	12,195	−55.9	----
175	21	12,957	−57.4	----	24	12,879	−55.7	----	30	13,267	−61.2	----	21	13,224	−62.9	----	28	13,214	−61.3	----	24	12,834	−54.7	----	25	13,034	−58.7	----
150	15	13,923	−58.3	----	24	13,857	−56.8	----	29	14,206	−68.7	----	7	14,169	−70.0	----	25	14,162	−67.5	----	23	13,816	−55.0	----	22	14,001	−60.9	----
125	----	----	----	----	23	15,006	−57.5	----	26	15,282	−75.2	----	----	----	----	----	22	15,249	−73.2	----	21	14,993	−55.7	----	19	15,118	−63.1	----
100	----	----	----	----	19	16,413	−57.0	----	7	16,558	−78.3	----	----	----	----	----	7	16,509	−74.5	----	18	16,415	−55.2	----	11	16,479	−62.6	----
80	----	----	----	----	15	17,836	−56.6	----	----	----	----	----	----	----	----	----	----	----	----	----	12	17,836	−54.3	----	8	17,851	−60.9	----
60	----	----	----	----	11	19,687	−54.9	----	----	----	----	----	----	----	----	----	----	----	----	----	8	19,651	−52.9	----	----	----	----	----
50	----	----	----	----	7	20,876	−54.7	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

See footnotes at end of table.

TABLE 1.—*Mean dynamic height (geopotential) in units of 0.98 dynamic meters, temperature in degrees centigrade, and relative humidity in percent, for standard pressures, as obtained by radiosondes during September 1948*—Continued

Standard pressure surface (mb.)	Washington, D. C. (1,015.6 mb.)				Standard pressure surface (mb.)	Washington, D. C. (1,015.6 mb.)			
	Number of observations	Dynamic height	Temperature	Relative humidity		Number of observations	Dynamic height	Temperature	Relative humidity
Surface	30	25	19.8	77	450	30	6,615	−16.6	----
1,000	30	159	19.9	68	400	30	7,484	−22.9	----
950	30	602	17.9	61	350	29	8,450	−29.7	----
900	30	1,061	15.0	61	300	29	9,531	−37.4	----
850	30	1,543	12.2	59	250	29	10,776	−46.1	----
800	30	2,049	9.7	54	200	25	12,217	−54.8	----
750	30	2,584	6.9	50	175	22	13,068	−59.4	----
700	30	3,146	3.9	52	150	17	14,018	−62.7	----
650	30	3,747	.7	44	125	9	15,124	−64.8	----
600	30	4,384	−2.7	40	100	8	16,481	−64.6	----
550	30	5,070	−6.4	----	80	6	17,836	−63.7	----
500	30	5,808	−11.1	----					

1 Data not yet received.
* Temperature and relative humidity data for this level are not available or are available only for certain days. See note entitled "Change in Summarization of Radiosonde Data," p. 6, in the January 1946 issue of the MONTHLY WEATHER REVIEW.

NOTE.—All observations scheduled between 0300 and 0500, G. C. T. except at Ciudad Victoria, Mazatlan, and Merida, where they are taken near 0200 G. C. T. "Number of observations" refers to those of dynamic height only. (In a few cases temperature or humidity data may be missing for one or more standard pressure surfaces of some observations.) Relative humidity data are not published for standard pressure surfaces having a corresponding mean temperature below −20° C.

All relative humidity observations are obtained by electric hygrometer and have been adjusted to compensate for the values occurring below the operating range of the humidity element. For explanation of the adjustment, see article entitled "Curve Method for Obtaining Monthly Means of Relative Humidity," p. 241, MONTHLY WEATHER REVIEW, December 1944.

None of the means included in these tables are based on less than 15 observations at the surface or 5 observations at a standard pressure level.

TABLE 2.—*Free-air resultant winds based on pilot balloon observations made near 2200 G. C. T., during September 1948. Directions given in degrees from north (N=360°, E=90°, S=180°, W=270°). Speeds in meters per second*

Altitude (meters) m. s. l.	Abilene, Tex. (534 m.)			Albuquerque, N. Mex. (1,627 m.)			Atlanta, Ga. (299 m.)			Billings, Mont. (1,095 m.)			Bismarck, N. Dak. (512 m.)			Boise, Idaho (868 m.)			Brownsville, Tex. (7 m.)			Buffalo, N. Y. (220 m.)			Burlington, Vt. (100 m.)			Charleston, S. C. (16 m.)			Cincinnati, Ohio (273 m.)			Denver, Colo. (1,618 m.)			El Paso, Tex. (1,198 m.)		
	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed
Surface	30	106	2.4	30	224	2.1	28	79	1.6	30	117	0.2	30	162	2.7	30	300	2.2	29	66	3.4	30	288	1.5	30	293	0.8	27	82	2.8	30	311	0.6	30	57	1.8	30	148	0.9
500							28	78	2.2										29	61	3.6	30	280	2.4	30	265	1.7	26	83	3.6	30	291	.9						
1,000	30	103	2.7				28	59	2.5				30	172	2.6	30	295	1.9	28	52	2.4	30	278	2.8	30	279	3.4	25	71	3.4	30	249	.6						
1,500	30	102	2.3				25	82	1.5	30	243	.7	29	200	3.4	30	251	1.0	26	43	2.1	30	286	3.1	28	280	4.3	23	53	1.7	30	200	.4				30	138	1.6
2,000	29	206	2.6	30	230	1.9	23	76	1.3	29	246	1.8	28	220	4.0	30	235	1.6	25	11	2.2	28	283	3.4	25	290	5.2	19	4	1.2	28	292	.7	30	80	2.9	30	143	1.4
2,500	29	101	2.6	30	216	1.2	21	47	1.3	28	255	3.8	28	244	5.5	29	243	3.5	24	13	2.5	23	281	4.2	25	297	6.9	18	358	2.3	24	305	1.9	30	95	3.0	30	117	1.0
3,000	26	73	2.1	30	238	1.1	17	62	.9	28	249	5.7	28	253	8.3	29	234	5.2	23	352	2.7	19	281	5.6	25	299	8.4	16	346	3.0	20	302	1.8	30	120	1.8	30	100	1.2
4,000	24	20	2.7	30	257	2.0	17	310	.4	26	254	9.4	26	263	9.2	27	244	9.0	22	327	2.6	16	295	8.1	23	303	9.5	13	320	4.4	16	330	2.4	29	228	3.4	28	85	.8
5,000	21	3	4.9	29	269	3.2	16	3	1.1	20	248	12.0	22	269	11.0	25	239	13.8	20	290	3.4	----	----	----	19	308	9.4	13	309	3.3	12	347	3.3	27	252	7.3	29	279	1.2
6,000	19	348	5.4	29	259	3.5	14	303	2.0	14	247	13.1	19	265	11.2	17	252	12.6	19	281	3.9	----	----	----	14	316	8.1	----	----	----	12	305	3.2	23	247	8.5	26	285	1.3
8,000	15	298	6.3	25	257	5.0	10	326	6.1	----	----	----	13	269	11.7	15	259	15.5	17	274	6.5	----	----	----	----	----	----	----	----	----	----	----	----	17	250	8.0	23	266	2.9
10,000	10	284	7.7	24	259	6.7	----	----	----	----	----	----	----	----	----	----	----	----	16	258	10.9	----	----	----	----	----	----	----	----	----	----	----	----	16	256	8.2	18	268	7.0
12,000	----	----	----	23	263	11.4	----	----	----	----	----	----	----	----	----	----	----	----	15	257	12.0	----	----	----	----	----	----	----	----	----	----	----	----	14	283	7.4	15	276	7.9
14,000	----	----	----	19	277	9.9	----	----	----	----	----	----	----	----	----	----	----	----	10	238	7.7	----	----	----	----	----	----	----	----	----	----	----	----	13	270	8.5	13	262	9.3

Altitude (meters) m. s. l.	Ely, Nev. (1,910 m.)			Grand Junction, Colo. (1,475 m.)			Greensboro, N. C. (271 m.)			Havre, Mont. (767 m.)			Jacksonville, Fla. (16 m.)			Joliet, Ill. (178 m.)			Las Vegas, Nev. (575 m.)			Little Rock, Ark. (88 m.)			Medford, Oreg. (416 m.)			Miami, Fla. (12 m.)			Mobile, Ala. (66 m.)			Nashville, Tenn. (182 m.)			New York N. Y. (15 m.)		
	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed
Surface	30	207	3.0	30	252	1.4	27	48	1.8	30	268	2.7	29	57	4.3	29	58	0.3	30	179	2.0	29	72	2.7	30	288	1.6	27	123	2.4	26	140	1.7	28	16	0.7	29	188	1.9
500	----	----	----	----	----	----	27	52	2.0	----	----	----	29	66	5.3	29	88	.9	----	----	----	29	77	2.3	30	297	1.6	27	141	3.6	26	121	2.3	28	49	.9	29	244	2.2
1,000	----	----	----	----	----	----	27	51	1.6	30	257	3.7	24	69	3.4	28	124	.1	30	186	3.8	28	82	2.3	30	297	1.4	26	149	2.5	24	91	1.9	28	131	.6	29	286	3.3
1,500	----	----	----	30	254	1.4	26	3	.7	30	248	4.5	23	124	.4	28	257	1.1	30	186	4.1	26	64	2.8	29	221	1.9	26	162	1.7	20	68	2.9	27	233	.5	29	294	4.2
2,000	30	211	3.2	30	252	2.2	25	35	.9	30	247	4.4	19	229	.8	27	288	2.2	30	195	3.9	25	65	3.3	27	210	4.2	24	172	1.7	18	66	2.4	26	227	.1	27	308	4.5
2,500	30	207	3.2	30	238	2.3	24	8	.5	29	247	7.2	18	227	1.3	24	287	3.5	30	208	4.8	23	56	3.5	25	211	4.3	21	185	1.9	16	61	1.8	25	308	.7	25	310	6.3
3,000	30	218	4.1	30	238	3.2	20	291	1.7	27	240	7.5	14	243	1.7	23	295	4.2	30	219	5.3	18	51	4.7	24	230	4.7	21	184	2.6	15	53	2.2	20	8	2.1	25	310	6.5
4,000	27	223	6.0	30	236	5.5	18	318	4.1	19	252	11.2	12	252	3.4	17	309	4.0	30	218	7.0	15	13	4.4	23	244	6.6	18	185	2.1	11	333	3.0	17	339	2.4	20	307	7.3
5,000	25	242	7.1	25	239	6.5	12	307	5.5	16	258	13.7	----	----	----	10	325	3.3	30	230	7.9	13	14	5.4	23	252	8.5	13	188	4.9	----	----	----	13	351	3.6	14	300	8.4
6,000	23	244	8.5	21	238	6.7	----	----	----	12	255	15.7	----	----	----	----	----	----	29	229	8.2	12	348	3.1	20	261	9.6	12	200	4.5	----	----	----	11	333	5.2	10	293	8.8
8,000	17	254	12.6	20	248	8.5	----	----	----	----	----	----	----	----	----	----	----	----	26	238	7.4	----	----	----	15	266	12.2	----	----	----	----	----	----	----	----	----	----	----	----
10,000	14	254	17.7	16	285	11.9	----	----	----	----	----	----	----	----	----	----	----	----	20	271	8.5	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
12,000	10	249	17.0	14	294	15.6	----	----	----	----	----	----	----	----	----	----	----	----	15	267	10.3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
14,000	----	----	----	10	289	12.1	----	----	----	----	----	----	----	----	----	----	----	----	13	279	10.2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	10	273	9.6	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

TABLE 2.—*Free-air resultant winds based on pilot balloon observations made near 2200 G. C. T., during September 1948. Directions given in degrees from north (N=360°, E=90°, S=180°, W=270°). Speeds in meters per second*—Continued

Altitude (meters) m. s. l.	Oakland, Calif. (8 m.)			Oklahoma City, Okla. (396 m.)			Omaha, Nebr. (306 m.)			Phoenix, Ariz. (338 m.)			Rapid City, S. Dak. (982 m.)			St. Cloud, Minn. (318 m.)			St. Louis, Mo. (181 m.)			San Antonio, Tex. (240 m.)			San Diego, Calif. (13 m.)			Sault Ste. Marie, Mich. (225 m.)			Seattle, Wash. (116 m.)			Spokane, Wash. (725 m.)			Washington, D. C. (24 m.)		
	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed
Surface	30	268	4.6	30	155	3.4	30	148	2.1	30	237	0.7	30	138	2.0	29	174	1.6	29	360	1.4	29	79	3.1	30	274	3.2	28	284	1.5	28	299	1.0	30	221	1.9	29	188	0.7
500	30	303	3.2	30	153	3.5	30	165	3.1	30	249	1.2	----	----	----	29	172	2.1	29	9	1.9	29	72	3.5	30	274	2.7	28	278	1.7	28	234	1.7	----	----	----	29	230	1.0
1,000	30	309	2.1	29	153	3.7	30	174	3.7	30	230	1.4	30	140	1.9	29	173	3.1	26	20	1.2	29	74	3.5	30	288	2.2	28	275	2.2	27	208	3.2	30	212	3.2	29	245	.9
1,500	29	284	1.9	29	157	2.6	30	189	3.4	30	188	1.6	30	169	2.5	29	218	4.0	26	353	.4	28	62	3.5	30	276	2.1	25	290	3.1	26	202	3.6	30	211	3.5	29	290	1.2
2,000	28	269	1.8	28	147	2.1	29	225	2.9	30	170	2.8	30	179	3.3	28	240	4.6	25	360	1.1	26	51	3.2	30	263	1.8	24	313	3.4	22	198	3.9	28	208	4.7	29	313	2.5
2,500	28	256	2.9	26	150	1.5	26	251	3.9	30	186	2.6	29	214	4.5	26	249	5.4	21	314	1.9	24	56	2.8	30	228	1.6	21	288	4.8	20	208	3.4	27	212	5.2	27	296	3.8
3,000	28	250	4.0	26	67	.3	26	266	4.3	30	208	2.5	28	234	5.6	25	257	5.0	20	302	2.7	22	48	3.5	30	200	2.8	17	294	6.5	18	221	2.9	27	216	6.2	27	294	4.7
4,000	27	242	5.6	23	293	2.9	25	293	4.6	28	218	2.1	26	260	6.5	23	287	5.4	28	337	3.3	21	355	4.4	29	195	4.4	16	305	7.5	17	248	2.4	23	243	5.7	22	300	5.0
5,000	26	244	7.1	19	322	4.2	23	309	5.7	25	189	1.7	24	255	7.8	21	286	5.5	15	297	5.9	18	358	3.8	28	204	4.6	15	299	8.9	16	260	5.2	17	248	8.7	21	306	6.4
6,000	26	259	8.6	16	306	5.1	21	307	5.4	24	225	1.0	21	263	9.8	21	303	5.8	12	303	5.7	14	332	3.9	28	224	4.2	10	305	9.9	13	268	6.2	13	247	9.2	21	294	8.0
8,000	23	272	11.7	----	----	----	19	304	7.5	12	347	3.9	16	272	13.6	18	297	9.1	10	296	9.1	----	----	----	26	253	4.5	----	----	----	----	----	----	10	245	8.4	16	289	12.0
10,000	21	263	13.6	----	----	----	17	295	7.9	----	----	----	11	280	11.0	11	328	8.4	----	----	----	----	----	----	17	291	8.4	----	----	----	----	----	----	----	----	----	11	289	16.2
12,000	14	265	18.1	----	----	----	15	308	9.2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	11	285	10.6	----	----	----	----	----	----	----	----	----	----	----	----	----	----

TABLE 3.—*Free-air resultant winds based on rawin observations made near 0300 G. C. T., during September 1948. Directions given in degrees from north (N=360°, E=90°, S=180°, W=270°). Speeds in meters per second*

Altitude (meters) m. s. l.	Albuquerque, N. Mex. (1,636 m.)			Big Spring, Tex. (774 m.)			Bismarck, N. Dak. (505 m.)			Brownsville, Tex. (7 m.)			Caribou, Maine (191 m.)			Charleston, S. C. (13 m.)			Columbia, Mo. (237 m.)			Grand Junction, Colo. (1,473 m.)			Greensboro, N. C. (275 m.)			Hatteras, N. C. (3 m.)			International Falls, Minn. (358 m.)			Little Rock, Ark. (80 m.)			Miami, Fla. (12 m.)		
	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed
Surface	30	140	2.9	30	138	3.1	30	107	2.9	30	76	1.3	30	276	1.8	30	55	1.5	30	92	1.2	30	96	0.8	28	59	1.3	30	48	2.1	30	125	1.0	30	49	1.1	29	94	1.8
500	----	----	----	----	----	----	----	----	----	30	68	5.2	30	307	4.4	30	88	4.7	30	131	2.2	----	----	----	27	87	2.1	28	55	2.1	30	170	2.0	30	80	4.0	29	105	3.7
1,000	----	----	----	30	135	6.0	30	150	4.7	30	51	5.0	30	315	5.5	30	84	4.3	30	126	2.0	----	----	----	27	83	2.4	28	53	1.3	30	211	3.7	30	74	4.1	29	103	3.3
1,500	----	----	----	30	131	5.9	30	194	4.7	30	36	4.4	30	329	6.6	30	78	2.8	30	145	.7	30	105	.8	28	44	1.9	28	19	.8	28	251	4.8	30	62	3.1	29	97	2.8
2,000	30	169	2.8	30	126	3.4	30	227	5.6	30	27	4.4	29	316	6.9	29	68	1.3	30	303	.9	30	205	1.5	28	36	1.9	29	347	1.1	28	263	4.4	30	51	3.1	29	107	1.8
2,500	30	196	2.7	30	97	1.6	29	244	6.3	30	20	3.4	28	305	7.5	29	339	.3	30	335	2.2	30	215	2.2	28	35	1.8	29	300	1.6	29	271	5.3	30	42	3.5	28	128	2.2
3,000	30	214	2.0	30	58	1.6	29	260	7.4	30	16	2.8	28	301	7.9	29	280	1.2	30	355	3.7	30	222	3.2	28	349	1.2	30	326	2.3	30	276	6.2	29	35	4.4	28	150	1.6
4,000	30	280	2.6	30	19	3.3	29	263	8.3	29	326	1.8	26	287	9.5	29	266	1.7	30	357	5.4	29	226	4.0	28	302	1.7	30	328	3.5	30	277	8.3	29	14	5.3	28	191	2.0
5,000	29	320	2.1	27	26	4.4	29	263	9.0	29	309	1.4	25	289	8.9	29	259	3.3	30	343	5.8	29	243	4.3	27	304	3.7	30	293	4.8	30	281	9.4	29	1	5.9	28	213	2.1
6,000	28	301	2.7	27	17	3.1	27	265	10.9	27	286	2.6	22	279	10.0	28	263	5.6	30	334	6.7	29	257	6.4	25	290	5.6	30	280	6.9	28	281	9.8	29	349	6.0	26	230	2.9
8,000	27	281	3.3	23	305	2.8	24	263	14.2	28	279	5.4	20	275	11.8	27	258	10.5	30	319	7.7	29	253	8.6	23	277	11.7	30	277	11.5	25	279	11.1	29	319	4.7	20	233	3.4
10,000	24	281	6.2	21	272	8.3	21	252	18.4	27	263	9.0	17	260	13.6	27	262	15.5	29	297	10.2	27	258	11.9	22	266	15.0	29	276	16.2	22	284	13.1	28	268	7.5	25	269	4.7
12,000	19	274	9.0	21	264	11.3	21	254	20.7	25	257	11.4	10	261	14.5	25	268	20.2	27	297	12.2	25	269	12.2	22	273	21.6	28	282	23.3	20	281	15.6	26	251	14.4	24	293	7.4
14,000	16	267	9.8	21	263	9.0	17	247	15.4	23	237	10.2	----	----	----	19	287	16.6	21	292	11.9	21	259	13.4	22	278	20.8	25	292	18.8	17	294	10.0	21	252	12.5	24	298	7.1
16,000	14	273	9.0	15	269	4.0	10	253	9.5	17	178	9.4	----	----	----	16	305	10.2	----	----	----	10	272	8.2	10	275	11.2	----	----	----	----	----	----	17	271	5.7	12	332	3.0
18,000	----	----	----	----	----	----	----	----	----	13	105	7.3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

Altitude (meters) m. s. l.	Nantucket, Mass. (14 m.)			Nashville, Tenn. (180 m.)			New Orleans, La. (6 m.)			Oakland, Calif. (8 m.)			Oklahoma City, Okla. (392 m.)			Rapid City, S. Dak. (980 m.)			St. Cloud, Minn. (318 m.)			San Antonio, Tex. (242 m.)			San Juan, P. R. (28 m.)			Santa Maria, Calif. (72 m.)			Sault Ste. Marie, Mich. (221 m.)			Spokane, Wash. (726 m.)			Tatoosh, Island, Wash. (33 m.)		
	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed	Observations	Direction	Speed
Surface	30	252	0.8	30	65	2.2	29	68	1.9	30	291	3.4	30	119	3.4	30	216	0.5	30	147	1.4	30	74	1.6	30	126	2.8	29	274	2.3	30	319	0.7	29	215	1.6	29	211	5.8
500	28	288	3.0	30	87	3.0	29	87	4.2	30	298	4.4	29	123	5.0	----	----	----	29	144	3.0	30	91	4.2	30	105	6.7	29	331	3.9	30	339	1.8	----	----	----	28	227	1.8
1,000	28	338	2.9	30	105	3.2	29	84	4.3	30	286	3.4	28	135	6.3	29	203	.5	28	158	3.6	30	91	5.5	30	99	7.1	29	360	3.3	29	277	2.7	29	222	2.6	28	235	2.1
1,500	27	336	4.9	29	106	2.8	29	84	3.6	30	275	2.4	29	144	4.0	28	166	2.2	28	205	2.8	30	82	4.6	30	93	7.2	29	9	2.2	29	272	4.0	29	244	3.6	28	237	2.0
2,000	28	327	5.0	28	107	2.0	29	94	2.7	29	248	2.7	30	166	2.8	28	190	2.8	29	255	3.1	30	71	4.3	30	93	7.0	29	304	.4	29	274	4.7	29	240	4.7	28	246	2.4
2,500	28	327	5.1	28	66	1.3	27	113	1.5	29	242	2.8	30	155	.6	28	210	3.5	30	262	4.1	30	59	4.0	30	96	7.0	28	256	2.4	28	256	5.5	27	239	6.3	28	260	3.5
3,000	27	322	6.0	27	37	1.7	28	198	.7	29	236	3.4	30	4	1.0	28	246	4.7	30	271	3.9	30	62	4.0	30	92	6.0	28	262	3.8	27	307	5.0	26	234	7.5	28	271	4.5
4,000	25	313	8.0	27	322	2.1	27	203	1.3	29	232	4.8	30	5	3.7	28	263	6.8	29	283	5.5	30	34	4.5	30	88	4.8	27	252	5.4	26	321	6.4	23	239	7.8	28	272	6.5
5,000	24	297	9.5	25	305	3.5	27	246	2.9	27	243	5.9	30	3	4.4	28	268	8.6	28	294	6.0	30	21	4.7	30	98	3.5	28	259	6.1	23	317	8.2	20	250	9.0	27	274	8.0
6,000	20	295	12.8	25	302	4.6	27	248	4.7	27	256	6.8	30	352	5.5	29	262	10.4	28	286	7.8	30	5	3.8	29	91	3.9	28	255	8.3	21	315	8.0	18	253	11.5	26	264	9.2
8,000	17	285	14.3	25	291	8.1	26	249	9.8	25	255	12.4	29	342	6.1	29	264	14.2	27	288	10.5	30	320	4.5	27	97	3.3	26	256	10.3	18	335	11.0	14	297	12.3	20	275	11.3
10,000	16	278	18.4	22	279	14.7	26	254	16.1	21	255	15.0	28	304	9.1	30	258	16.5	27	279	13.4	30	277	9.1	26	53	1.7	25	263	12.2	13	339	12.5	10	259	12.6	16	282	12.6
12,000	12	284	15.3	19	278	19.1	21	262	17.8	18	271	18.5	25	283	12.4	30	264	14.6	24	278	12.9	30	275	12.7	26	21	2.8	22	271	16.5	----	----	----	----	----	----	16	281	14.1
14,000	----	----	----	16	284	16.0	19	268	15.1	15	267	25.1	22	265	12.7	28	266	15.2	21	287	12.5	29	279	13.5	24	12	7.1	19	266	16.5	----	----	----	----	----	----	14	285	11.5
16,000	----	----	----	----	----	----	----	----	----	11	261	17.8	13	300	7.3	21	265	12.4	10	287	10.7	----	----	----	18	42	2.8	14	264	8.5	----	----	----	----	----	----	12	271	9.1
18,000	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	10	268	4.7

NOTE.—Resultants prepared from rawins at high altitudes are biased toward lower wind speeds. Values appearing in this table should therefore be used with caution when the number of observations missing is greater than three. See note following Table 3 in the June 1948 issue of the MONTHLY WEATHER REVIEW.

RIVER STAGES AND FLOODS FOR SEPTEMBER 1948

ELMER R. NELSON

River stages were mostly below normal during September east of the Mississippi River, except in an area extending north to northeastward from Georgia to the central portion of Ohio and the southwestern tip of Pennsylvania. West of the Mississippi it was above normal in the north-central portion and at a few other widely scattered points. The greatest negative departure was at Vicksburg, Miss., where the Mississippi River averaged 8 feet below normal. The greatest positive departure was at Swan Lake, Miss., where the Tallahatchie averaged 10.2 feet above normal. The only flooding during the month was on the lower Rio Grande in Texas, the Atchafalaya in Louisiana, and the Broad River in South Carolina.

Precipitation during the month was below normal except along portions of the coastal areas of the Middle and South Atlantic States, the Gulf States, and the Pacific Northwest. It was also above normal at a few scattered inland points. The greatest precipitation (twice normal) occurred along the Gulf Coast. Heavy rains occurred over southern Florida in connection with the hurricane of September 21, causing extensive flooding in the Lake Okeechobee area. The section most severely inundated occurred in the vicinity of Clewiston, where 15 inches of rain occurred during and just prior to the storm.

Atlantic Slope drainage.—Excessive rains (7.70 inches) occurred over the Broad River in the vicinity of Blairs, S. C., on the 6th, with most of it falling between 8 a. m. and 12 noon, causing light flooding at that point but no damage of consequence. High stages, however, were reached on the small streams in the vicinity, causing washouts in the road and railroad beds. A Southern Railroad passenger train ran into a washed-out culvert about ¼ mile north of Blairs, killing the fireman, injuring the engineer, and causing considerable damage to the train. Crops were badly damaged in the area.

Atchafalaya Basin.—Light flooding occurred on the Atchafalaya River at Morgan City, La., on the 13th, due to strong south and southeast winds caused by the passage of a small cyclonic disturbance over southwestern Louisiana. These winds caused the water to back up the river to slightly above bank-full stage from 6:15 a. m. to 2:50 p. m. No damage was reported.

West Gulf of Mexico drainage.—Heavy rains over southern Texas during the second week of the month caused light to moderate flooding on the lower Rio Grande below Rio Grande City, Tex.

FLOOD STAGE REPORT FOR SEPTEMBER 1948

[All dates in September unless otherwise specified]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC SLOPE DRAINAGE					
	Feet			*Feet*	
Broad: Blairs, S. C.	14	7	7	15.8	7
MISSISSIPPI SYSTEM					
Atchafalaya Basin					
Atchafalaya: Morgan City, La.	6	13	13	6.5	13
WEST GULF OF MEXICO DRAINAGE					
Rio Grande:					
Rio Grande City, Tex.	21	11	12	33.0	12
Hidalgo, Tex.	21	13	15	22.7	14
Mercedes, Tex.	21	12	17	23.1	14
Brownsville, Tex.	18	16	17	18.4	16

ESTIMATED FLOOD LOSSES FOR 1946[1]

BENNETT SWENSON

Monetary losses from floods in the United States during 1946, estimated at about $71,000,000, were considerably smaller than in the two previous years. The loss in life was considerably less than in 1945, with 28 lives lost as compared with 91 during 1945. The savings resulting from the flood forecasting and warning service was reported at about $5,500,000.

A major flood with record stages occurred in the Susquehanna River Basin during the last few days of May, causing considerable property damage and loss of several lives. Unusual early floods occurred in eastern Iowa and adjoining portions of Illinois, Wisconsin, and Minnesota in January. The greatest flood since September 1921, occurred in the vicinity of San Antonio, Tex., during September, with the loss of several lives and property damage of several million dollars.

[1] Flood loss statistics for 1944 and 1945 were published in the June 1948 issue of the MONTHLY WEATHER REVIEW.

ESTIMATED FLOOD LOSSES FOR 1946—Continued

River and drainage	Tangible property	Matured crops	Prospective crops	Livestock and other movable farm property	Suspension of business	Total	Lives lost
HUDSON BAY DRAINAGE							
Red River of the North	$13,300					$13,300	
ST. LAWRENCE DRAINAGE							
Lakes Michigan and Huron							
Grand and Saginaw Rivers	130,500			$10,000	$9,800	150,300	
Fox River	12,000					12,000	
Total	142,500			10,000	9,800	162,300	
Lake Erie							
Sandusky River			$75,000			75,000	
ATLANTIC SLOPE DRAINAGE							
Connecticut River	13,000					13,000	
Schuylkill River and Perkiomen Creek	456,700				80,700	537,400	2
Tioga River						[1] 650,000	
Susquehanna River						[1] 7,300,000	12
Pee Dee River					14,500	14,500	
Saluda River				1,000		1,000	
Broad River			1,000		1,000	2,000	
Congaree River	15,000		18,000	400	43,000	76,400	
Catawba and Wateree Rivers	5,000				2,500	7,500	
Santee River					50,000	50,000	
Oconee River						[1] 15,900	
Altamaha River					5,000	5,000	
Total	489,700		19,000	1,400	196,700	8,672,700	14
EAST GULF OF MEXICO DRAINAGE							
Chattahoochee River						[1] 349,200	
Apalachicola River					9,000	[2] 25,500	
Choctawhatchee River	623,400	$15,000	1,283,500	14,800	36,300	1,973,000	
Etowah, Oostanaula, Coosa, Alabama, and Cahaba Rivers	150,000	75,000		1,000	25,000	251,000	
Tombigbee and Black Warrior Rivers	160,800	10,800	500	5,000	64,500	241,600	
Pearl River	26,500		9,000	17,000	70,000	122,500	
Total	960,700	100,800	1,293,000	37,800	204,800	2,962,800	
MISSISSIPPI SYSTEM							
Upper Mississippi Basin							
Crow Wing River	45,000		35,000			80,000	
Chippewa River	20,800		1,500			22,300	
Zumbro and Whitewater Rivers	7,400				500	7,900	
Trempealeau River	1,000					1,000	
Black River	27,000				1,000	28,000	
Bad and White Rivers	1,930,200	6,000	30,000	27,000	200,000	2,193,200	
Root River	76,000	21,600		2,800	3,200	103,600	
Crooked Creek	415,000	1,000	50,000	20,000	10,000	496,000	
Upper Iowa River and tributaries	73,900	4,000	2,500	500	4,800	85,700	
Kickapoo River	53,100	600		300	4,000	58,000	
Wisconsin River	5,000					5,000	
Rock River	22,000	2,500			2,000	26,500	
Skunk River	36,600		343,700	200		380,500	
Raccoon River	500		5,000	100		5,600	
Des Moines River	461,600	102,600	533,000	10,400	2,000	1,109,000	4
Fox River	155,000		260,000	3,500	12,700	431,200	
Salt River	1,500		800			2,300	
Illinois River		30,000				30,000	
Mississippi River (above Cape Girardeau, Mo.)	1,628,400	657,600	1,087,300	54,200	88,400	3,515,900	
Total	4,960,000	885,300	2,348,800	119,000	329,200	8,642,300	4
Missouri Basin							
Yellowstone River	250,900		81,100		3,700	335,700	
Cheyenne River	351,000	18,300		1,200	10,000	380,500	
Platte River	2,400	2,000				4,400	
Nishnabotna River	32,200	3,800	4,000	400	4,000	44,400	
Solomon River	148,700		310,500	500	3,500	463,200	
Saline River	51,400		78,800			130,200	
Smoky Hill River	20,300		89,000		2,000	111,300	
Republican River	449,500		743,500	400	1,000	1,194,400	
Blue River	13,800		86,600			100,400	
Elkhorn River	800					800	
Wakarusa River	10,700		94,500	100		105,300	
Grand River	59,900	130,400				190,300	
Chariton River	312,700	2,135,200			10,100	2,458,000	
Osage River	78,600	504,600				583,200	
Gasconade River	61,700	503,000		300	500	565,500	
Missouri River and minor tributaries	1,019,500	18,300	574,700	3,500	21,600	1,637,600	
Total	2,864,100	3,315,600	2,062,700	6,400	56,400	8,305,200	

See footnotes at end of table.

ESTIMATED FLOOD LOSSES FOR 1946—Continued

River and drainage	Tangible property	Matured crops	Prospective crops	Livestock and other movable farm property	Suspension of business	Total	Lives lost
MISSISSIPPI SYSTEM—continued							
Ohio Basin							
Allegheny River						[1] $600,300	
Four-Pole Creek	$19,000					19,000	
Big Sandy River	277,900	$25,000		$1,100	$17,000	321,000	
Scioto and Olentangy Rivers	16,500		$1,311,000			1,327,500	
Wabash and White Rivers	1,000	10,500	500		6,000	18,000	
Cumberland River						[1] 3,916,200	
French Broad River	4,800	200	1,000			6,000	
Tennessee River	1,298,900		2,694,200		647,400	4,640,500	
Ohio River	1,200	61,600		200	2,000	65,000	
Total	1,619,300	97,300	4,006,700	1,300	672,400	10,913,500	
White Basin							
White River	107,600	392,700	28,000	11,000	230,800	770,100	
Arkansas Basin							
Cottonwood River	56,300	3,000	180,000	5,300	3,000	247,600	
Neosho River	38,400	600	32,000	2,000	300	73,300	
North Canadian River	107,200		[3] 470,900			578,100	
Poteau River	500		20,000	2,100	26,800	49,400	
Arkansas River		73,000				73,000	
Total	202,400	76,600	702,900	9,400	30,100	1,021,400	
Red Basin							
Ouachita River	136,700	45,100	30,300	18,500	39,800	270,400	
Little River	8,500	1,000	100,000	7,500		117,000	
Sulphur River	65,000	10,000	24,800	11,400	11,500	122,700	
Red River	419,200	10,000	40,000	55,000	400,000	924,200	
Total	629,400	66,100	195,100	92,400	451,300	1,434,300	
Lower Mississippi Basin							
St. Francis River	100,000	250,000	15,000	2,000	30,000	397,000	
Tallahatchie River			10,000			10,000	
Yazoo and Coldwater Rivers	2,000,000	10,000	545,000	10,000	550,000	3,115,000	
Mississippi River (below Cape Girardeau, Mo.)	250,000	500,000	50,000	10,000	75,000	885,000	
Total	2,350,000	760,000	620,000	22,000	655,000	4,407,000	
WEST GULF OF MEXICO DRAINAGE							
Sabine River	145,700	1,200	58,000	24,700	54,600	284,200	
San Antonio and Nueces Rivers	5,867,500	384,000	342,000	37,300	252,500	6,883,300	9
Trinity River	822,500	3,246,200	4,345,200	53,500	122,900	8,590,300	1
Guadalupe River	125,000	78,000	3,500	2,500		209,000	
Total	6,960,700	3,709,400	4,748,700	118,000	430,000	15,966,800	10
GREAT BASIN DRAINAGE							
San Pitch River	89,800		4,700	300	5,000	99,800	
PACIFIC SLOPE DRAINAGE							
Columbia Basin							
Kootenai River			18,200			18,200	
Potlatch Creek	163,200				5,000	168,200	
Willamette River						[1] 5,528,000	
Total	163,200		18,200		5,000	5,714,400	
Puget Sound							
Green River	528,800	35,000		40,000	55,000	658,800	
Cedar River	55,000					55,000	
Snohomish River	16,000	[4] 771,000		2,300	9,500	798,800	
Skagit Basin and Nooksack River	140,000					140,000	
Total	739,800	806,000		42,300	64,500	1,652,600	
Grand total	22,292,500	10,209,800	16,122,800	471,300	3,341,000	70,813,500	28

[1] Unclassified.
[2] Includes losses of $16,500 which were not classified.
[3] Includes all farm losses.
[4] Includes all crop losses.

CLIMATOLOGICAL DATA FOR SEPTEMBER 1948

CONDENSED CLIMATOLOGICAL SUMMARY OF TEMPERATURE AND PRECIPITATION BY SECTIONS

[For description of tables and charts, see REVIEW, January 1948, p. 15]

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Section	Temperature								Precipitation					
			Monthly extremes								Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	73.5	−2.2	Frisco City	101	1	Valley Head	43	24	4.58	+1.34	Gulf Shores	13.27	Tuskegee	1.35
Arizona	74.5	+1.7	Parker	120	3	Fort Valley	24	23	.70	−.63	Y-Lightning Ranch	3.74	5 stations	.00
Arkansas	72.6	−1.7	2 stations	102	[1]7	Batesville Livestock	35	28	.88	−2.41	Big Lake Outlet	4.68	2 stations	.00
California	67.8	0.0	Cow Creek	121	1	Twin Lakes	10	26	.29	−.10	Willits Howard R. S.	4.34	314 stations	.00
Colorado	61.1	+3.0	Lamar	103	1	Marshall Pass	10	10	.63	−.72	Cascade	2.26	Lime (near)	.00
Florida	79.2	−.3	Fellsmere	100	6	2 stations	54	[1]28	10.37	+3.62	Clewiston	24.51	Cedar Key	2.45
Georgia	70.5	−2.2	4 stations	100	1	Blairsville Exp. Sta.	45	13	4.09	+.46	Brunswick	9.32	Jasper	1.58
Idaho	57.7	+.6	2 stations	101	[1]2	Obsidian, 4 NNE	15	24	1.18	+.10	Jerome	3.56	stations	T
Illinois	68.8	+1.0	Urbana Water Works	99	14	Freeport	37	27	2.84	−.83	Marshall, 1 W	7.39	Greenville	.72
Indiana	68.1	+.9	8 stations	96	[1]12	Plymouth	37	27	2.71	−.59	Farmersburg, 3 SW	7.01	Henryville State Forest.	.57
Iowa	68.0	+3.6	Boone	102	19	Elkader	31	27	2.10	−1.92	Malvern	6.34	Sioux City, 8 N	.07
Kansas	71.9	+2.1	Phillipsburg	107	1	Atwood	29	30	1.57	−1.26	Emporia	8.09	Coffeyville	.07
Kentucky	69.6	−.8	Williamsburg	98	21	Hindman Settlement School.	36	[1]25	1.92	−.98	Murray	4.70	Williamstown	.2
Louisiana	75.8	−2.1	Abbeville	104	7	3 stations	45	[1]29	5.77	+1.69	Port Sulphur	19.75	Gloster	T
Maryland — Delaware.	66.9	−.9	Blackwater, Md.	95	[1]6	Oakland, Md.	29	27	2.70	−.57	Ocean City, Md.	8.15	Dover, Del.	1.03
Michigan	63.4	+3.0	Bad Axe, 5 NW	96	11	Kenton U. S. Forest	19	22	1.64	−1.57	Three Rivers	4.19	Detour, 1 N	.32
Minnesota	63.4	+4.4	Fosston Power Plant	100	2	Allen Junction	21	22	1.66	−1.22	Artichoke Lake	5.10	Argyle	.16
Mississippi	73.2	−2.7	Port Gibson	98	9	3 stations	45	[1]25	5.51	+2.42	Gulf Port	14.41	Cleveland	1.15
Missouri	70.2	+.9	St. Charles	100	20	Anderson	38	27	2.14	−1.90	Sikeston	5.63	Seligman	.06
Montana	58.2	+2.9	Albion	104	15	Wisdom	13	6	.47	−.90	Hebgen Dam	1.68	4 stations	T
Nebraska	68.4	+4.0	Alma	107	[1]1	Cambridge	27	29	1.98	−.09	Firth	8.03	Lexington	.20
Nevada	63.5	+2.0	Overton	115	1	Fish Creek Ranch	9	[1]25	.35	−.06	Lamoille	2.97	7 stations	.00
New England	60.8	+.5	Franklin, 1 NW., N. H.	95	13	2 stations	24	[1]17	.97	−2.76	Nantucket, WB Apt., Mass.	3.62	Lawrence, Mass.	.03
New Jersey	66.3	+.4	Layton, 3 NW	95	13	Layton, 3 NW	28	22	1.16	−2.65	Phillipsburg	2.81	Macopin Intake	.11
New Mexico	66.5	+2.0	Orogrande	112	7	Eagle Nest	20	[1]29	.70	−1.02	Animas	2.56	33 stations	.00
New York	62.6	+1.3	Morrisville	99	4	Angelica	23	28	1.26	−2.22	Buffalo WB Apt	5.74	Schroon Lake	.04
North Carolina	68.8	−2.2	Goldsboro	98	21	Mt. Mitchell	30	26	4.51	+.44	Mortimer Exp. Sta.	11.56	Marshall	1.24
North Dakota	63.7	+7.0	Dunn Center	107	16	Parshall	24	9	.39	−1.18	Wahpeton State School.	1.54	28 stations	.00
Ohio	66.6	+.9	2 stations	98	17	Canfield, 1 S	31	25	2.84	−1.08	Logan	8.92	Chilo Dam 34	.30
Oklahoma	74.3	+.1	Frederick	107	7	Kenton	35	[1]28	.45	−2.69	Okeene	2.92	35 stations	.00
Oregon	58.0	+.1	2 stations	103	[1]8	Chemult	19	[1]15	1.89	+.70	Astoria	6.19	Adrian	.07
Pennsylvania	63.8	−.4	do	95	[1]13	Philipsburg	25	22	1.62	−1.81	West Chester	4.95	Dingman's Ferry	.17
South Carolina	71.6	−2.9	Orangeburg	99	1	Caesars Head	41	26	6.04	+1.95	Orangeburg No. 2	13.24	Belton	2.03
South Dakota	67.0	+5.4	Pine Ridge	110	15	5 stations	32	[1]8	1.13	−.41	Castlewood	3.83	Cottonwood	.04
Tennessee	70.4	−1.1	Dalehollow Dam	98	3	Waynesboro	38	24	3.37	+.31	Centerhill Dam	6.92	Oakridge No. 2	1.14
Texas	76.3	−1.0	Pecos	110	5	2 stations	34	[1]28	2.01	−.98	McAllen	9.65	4 stations	.00
Utah	63.3	+2.5	Zion Nat'l. Park	107	[1]1	Woodruff	18	27	.40	−.61	Blanding	2.15	do	.00
Virginia	67.1	−1.5	2 stations	95	21	Sugar Grove	30	26	3.39	+.15	Montebello	7.16	Rose Hill	1.00
Washington	57.4	−1.2	Lacrosse, 3 ESE	99	13	Stockdill Ranch	19	25	2.67	+.88	Quinault R.S	9.67	Richland, 2 SW	.04
West Virginia	65.3	−1.0	Logan	96	4	2 stations	28	26	3.16	+.19	Spruce Knobb	7.51	Athens	1.39
Wisconsin	64.9	+4.6	Wisconsin Rapids	99	16	Mellen Power Co. Dam.	23	22	1.96	−1.76	Goodrich	5.37	Superior Power Plant.	.39
Wyoming	59.7	+4.9	Shawnee	102	1	Bondurant	11	29	1.05	−.11	Grassy Lake Dam	2.57	Ft. Bridger	.04
Alaska (Aug.)	49.6	−3.0	Bell Island	86	14	Central	15	24	2.85	−.67	Attu	11.61	Wainwright	.40
Hawaii	74.7	+.1	Kaanapali	91	[1]2	Haleakala R. S.	40	10	4.94	−.35	Puohakamoa No. 2	33.00	Ukumehame	.00
Puerto Rico	78.9	+.4	Ponce	96	3	Garzas	57	7	10.76	+4.01	Rio Blanco (1800')	22.25	Cambalache Exp. Station.	2.07
Florida (Aug.)	81.2	−.3	De Funiak Springs	100	30	3 stations	62	[1]7	7.85	+.81	Lakeland	15.57	Lake Trafford	1.82
Hawaii (Aug.)	75.2	+.4	2 stations	91	[1]18	Haleakala R. S.	41	29	5.65	−.69	Iliiliula Intake	33.40	Puako	T

[1] Other dates also.

CLIMATOLOGICAL DATA FOR WEATHER BUREAU STATIONS FOR SEPTEMBER 1948

District and station	Elevation of instruments: Barometer above sea level [1]	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station	Pressure: Sea level	Pressure: Departure from normal	Temperature of the air: Averages: Mean maximum	Temperature of the air: Averages: Mean minimum	Temperature of the air: Averages: Mean	Temperature of the air: Averages: Departure from normal	Temperature of the air: Extremes: Highest	Temperature of the air: Extremes: Date	Temperature of the air: Extremes: Lowest	Temperature of the air: Extremes: Date	Temperature of the air: Extremes: Greatest daily range	Total heating degree days	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Greatest in 24 hours	Precipitation: Days with 0.01 inch or more	Precipitation: Days with thunderstorms	Precipitation: Total snowfall (unmelted)	Precipitation: Snow, sleet, and ice on ground at end of month	Wind: Average hourly speed	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Character of day (sunrise to sunset), number of days: Clear	Character of day (sunrise to sunset), number of days: Partly cloudy	Character of day (sunrise to sunset), number of days: Cloudy	Average cloudiness, tenths (sunrise to sunset)	Possible sunshine
NEW ENGLAND	Ft.	Ft.	Ft.	Mb.	Mb.	Mb.	°F.	°F.	°F.	°F.	°F.		°F.		°F.		°F.	%	In.	In.	In.			In.	In.	m. p.h.					0-3	4-7	8-10	0-10	%
									60.3	+1.9								78	1.46	−2.0															4.4	
Caribou [2]	628	5	33	992.9	1,015.9	----	67	44	55.6	+3.1	86	6	29	17	37	298	46	80	3.27	−.3	2.09	12	3	0.0	0.0	----	nw.	--	------	--	8	10	12	5.9	--
Eastport	75	67	82	1,013.2	1,015.9	−1.0	64	48	56.0	+.2	75	27	40	17	27	272	48	79	.92	−1.9	.38	7	1	.0	.0	8.4	s.	21	ne.	24	10	9	11	5.3	66
Portland, Maine [2]	103	6	43	1,013.2	1,016.9	−.7	74	46	60.2	+2.3	86	6	30	17	41	160	50	75	.30	−2.8	.20	2	2	.0	.0	7.1	nw.	25	n.	24	18	7	5	3.7	76
Concord [2]	289	5	45	1,007.1	1,018.0	.0	76	44	60.2	+2.2	93	13	28	17	46	184	48	74	.41	−3.0	.35	3	1	.0	.0	5.5	nw.	25	nw.	21	19	5	6	3.7	67
Mt. Washington	6,274	5	37	809.7	1,022.8	----	47	36	41.4	+.4	62	13	22	22	18	709	37	88	2.74	−4.7	1.15	6	2	.0	.0	22.6	w.	----	------	--	8	11	11	5.6	49
Burlington [2]	403	6	51	1,003.1	1,017.6	+.7	75	49	61.8	+1.5	92	13	33	16	36	163	52	78	.87	−2.6	.45	3	3	.0	.0	7.3	s.	30	s.	17	13	9	8	4.5	54
Boston [2]	124	33	62	1,013.2	1,017.7	+.1	75	56	65.7	+2.5	90	13	44	22	26	76	51	66	.67	−2.5	.73	5	1	.0	.0	9.5	nw.	36	nw.	18	16	7	7	3.9	81
Nantucket [2]	12	4	34	1,017.3	1,018.0	+.4	70	54	62.4	−.4	78	10	44	23	23	112	56	84	3.62	+1.8	2.48	4	3	.0	.0	10.1	sw.	33	n.	1	13	11	6	4.2	76
Block Island	26	11	46	1,016.6	1,017.6	.0	72	58	65.0	+1.6	81	8	49	22	21	63	58	84	1.01	−1.6	.43	4	2	.0	.0	11.1	sw.	42	nw.	18	15	9	6	4.0	74
Providence [2]	159	65	60	1,011.9	1,018.0	+.4	77	55	66.3	+3.1	90	13	43	17	31	68	54	78	2.36	−.8	1.32	5	3	.0	.0	6.5	sw.	25	nw.	18	16	7	7	3.6	81
Hartford [2]	159	5	44	1,012.5	1,018.3	+.3	78	51	64.6	+2.9	91	13	37	17	39	90	54	78	.63	−2.9	.35	3	1	.0	.0	6.1	s.	28	nw.	18	14	11	5	4.3	75
New Haven [2]	107	5	39	1,014.2	1,018.0	.0	76	54	64.9	+3.1	85	13	37	22	35	71	54	76	.70	−2.5	.50	5	2	.0	.0	5.8	ne.	18	sw.	18	14	11	5	4.4	71
MIDDLE ATLANTIC																																				
									67.5	+.9								77	2.04	−1.2															5.6	
Albany [2]	97	6	40	1,013.9	1,017.6	.0	77	49	63.0	+1.8	92	13	33	17	41	136	52	79	1.51	−1.3	.96	6	5	.0	.0	6.2	s.	32	nw.	18	11	10	9	4.8	68
Binghamton [4]	871	57	79	981.4	1,012.9	−5.1	67	46	56.6	−.8	88	11	32	2	36	278	46	76	5.07	+1.8	2.08	16	2	.0	.0	5.9	w.	25	sw.	9	2	9	20	7.9	37
New York [4]	314	415	454	1,007.1	1,018.3	+.3	77	61	69.3	+2.5	88	13	51	22	25	20	56	68	1.13	−2.3	.56	4	2	.0	.0	10.4	sw.	37	nw.	18	12	13	5	4.6	69
Allentown [2]	385	4	58	1,004.7	1,018.6	----	78	53	65.4	+.6	90	13	39	23	40	86	54	80	1.32	−2.1	.80	5	5	.0	.0	----	sw.	----	------	--	9	9	12	5.7	--
Harrisburg [2]	374	30	49	1,005.1	1,018.6	+.3	78	55	66.4	+.6	90	13	41	22	36	71	55	76	.77	−2.3	.28	7	2	.0	.0	5.4	w.	23	nw.	9	8	7	15	6.2	53
Philadelphia [4]	114	174	180	1,014.2	1,018.3	.0	78	61	69.5	+1.5	89	9	50	23	25	21	58	78	1.34	−1.9	.89	4	2	.0	.0	6.3	s.	24	nw.	18	9	12	9	5.4	65
Reading	323	47	306	1,006.8	1,018.6	+.3	78	57	67.4	+.8	91	13	44	27	35	50	----	--	3.02	−.2	1.65	7	4	.0	.0	7.6	n.	40	n.	9	9	7	14	5.9	61
Scranton	805	72	104	989.5	1,018.3	.0	76	53	64.6	+1.7	89	13	38	22	38	99	----	--	.90	−2.3	.30	9	3	.0	.0	5.2	n.	28	nw.	18	6	20	4	5.0	69
Atlantic City	52	37	172	1,015.9	1,017.6	−.4	74	62	68.2	+1.4	85	20	51	25	18	40	61	81	.64	−2.0	.39	2	1	.0	.0	12.6	n.	34	ne.	24	13	8	9	4.9	67
Newark [2]	30	5	46	1,016.9	1,018.0	.0	79	58	68.4	+1.9	93	13	46	27	35	31	56	72	1.14	−2.6	.58	5	1	.0	.0	----	sw.	----	------	--	9	14	7	5.1	--
Trenton	190	89	107	1,011.5	1,018.3	−.3	78	58	67.5	+.6	89	13	46	22	30	46	----	--	1.59	−1.8	1.27	4	3	.0	.0	6.7	n.	23	w.	9	8	14	8	5.2	56
Baltimore [4]	123	100	215	1,013.9	1,018.3	+.3	79	62	70.2	+1.7	93	13	50	23	25	25	58	74	2.27	−1.1	.82	7	4	.0	.0	7.8	n.	39	sw.	18	11	8	11	5.4	69
Washington [4]	112	56	100	1,014.6	1,018.3	+.3	79	60	69.7	+1.5	91	13	48	27	30	27	58	70	3.63	+.4	1.21	6	2	.0	.0	5.1	n.	25	nw.	9	8	10	12	5.8	72
Cape Henry	18	8	54	1,016.9	1,017.6	.0	77	66	71.8	.0	90	20	60	3	22	0	63	78	3.03	+.2	1.17	7	3	.0	.0	12.6	e.	38	n.	21	8	11	11	5.5	76
Lynchburg [2]	686	5	58	993.9	1,018.3	−.3	77	57	67.2	−.7	89	9	46	26	32	52	58	82	2.07	−1.2	1.12	10	2	.0	.0	7.2	n.	26	sw.	9	11	7	12	5.7	56
Norfolk [4]	91	80	125	1,014.9	1,018.3	.0	78	66	72.2	+.6	90	9	60	25	23	1	62	80	2.24	−1.0	.85	7	3	.0	.0	8.4	ne.	26	ne.	27	8	7	15	6.3	62
Richmond [4]	144	11	52	1,012.5	1,017.6	−.7	79	60	69.6	−.9	90	9	50	27	30	28	60	82	3.05	−.2	.79	7	3	.0	.0	5.6	n.	22	nw.	21	10	8	12	5.5	67
SOUTH ATLANTIC																																				
									72.6	−.3								78	4.90	+.8															6.7	
Asheville	2,253	77	92	944.8	1,018.3	−.3	77	56	66.4	+1.4	87	9	45	26	33	47	58	85	1.60	−1.4	.70	10	1	.0	.0	6.7	se.	27	e.	28	9	9	12	6.0	56
Charlotte [4]	779	63	86	989.8	1,017.6	−.4	80	62	71.0	−.5	92	21	52	26	28	18	59	73	3.07	+.1	1.22	9	0	.0	.0	5.5	ne.	19	ne.	27	8	8	14	5.7	63
Greensboro [2]	886	6	56	986.8	1,018.3	.0	80	58	68.8	−1.0	93	21	48	24	36	28	57	72	1.95	−1.3	1.36	8	1	.0	.0	7.4	ne.	25	ne.	26	10	7	13	5.5	53
Hatteras	11	5	47	1,016.3	1,016.6	−.7	78	71	74.5	.0	84	10	64	24	15	0	67	78	3.84	−.8	2.00	9	5	.0	.0	12.5	ne.	32	n.	23	11	5	14	6.0	59
Raleigh [4]	376	5	71	1,004.4	1,018.0	.0	81	62	71.2	+.1	94	20	50	25	30	14	60	76	4.01	+.4	1.97	10	4	.0	.0	6.3	ne.	15	ne.	27	4	15	11	6.2	48
Wilmington	72	73	107	1,015.9	1,017.3	−.3	81	66	73.5	+.4	92	10	54	25	22	1	64	80	7.23	+2.7	2.74	12	2	.0	.0	8.6	ne.	24	nw.	10	10	8	12	5.7	60
Charleston [4]	48	11	92	1,014.2	1,015.9	−1.0	81	69	75.4	−1.2	90	10	59	26	17	0	66	83	7.71	+3.2	2.55	15	5	.0	.0	11.0	ne.	26	ne.	17	6	11	13	6.2	53
Columbia, S. C. [4]	347	70	91	1,004.4	1,016.9	−.7	82	64	72.9	−1.6	93	9	53	25	27	7	63	77	5.31	+1.9	1.75	9	2	.0	.0	7.5	ne.	23	s.	3	11	5	14	5.8	54
Greenville, S. C. [3]	1,040	18	36	980.4	1,017.3	−.3	79	61	70.0	−.6	91	21	52	26	30	19	60	74	2.84	−.8	1.43	9	1	.0	.0	8.8	ne.	34	ne.	28	9	9	12	5.7	61
Augusta [4]	182	62	77	1,009.8	1,016.3	−.6	82	65	73.5	−1.8	94	9	55	26	28	4	63	74	8.04	+4.7	4.85	13	1	.0	.0	5.4	ne.	19	ne.	27	10	5	15	5.9	55
Savannah [2]	65	19	51	1,013.5	1,015.6	−1.0	84	68	76.0	+1.7	95	9	57	26	23	0	68	80	6.45	+1.0	3.00	11	4	.0	.0	9.4	ne.	26	ne.	25	6	12	12	6.1	42
Jacksonville [4]	43	86	110	1,012.9	1,014.6	−1.7	85	72	78.2	−.1	93	10	65	26	20	0	70	80	6.79	−.6	.87	20	5	.0	.0	8.3	e.	27	ne.	25	7	7	16	6.8	35
FLORIDA PENINSULA																																				
									81.3	+.5								81	9.26	+2.0															6.1	
Key West [4]	21	10	64	1,010.5	1,011.2	−2.7	88	77	82.2	+.5	92	10	72	26	16	0	75	80	13.84	+7.1	5.17	16	7	.0	.0	10.7	e.	73	nw.	21	4	20	6	5.5	57
Miami [4]	25	242	249	1,011.2	1,011.9	−3.0	85	76	80.6	−.3	90	6	70	26	15	0	74	84	10.57	+1.9	2.56	17	11	.0	.0	15.1	se.	62	se.	21	1	19	10	6.7	49
Tampa [2]	35	5	36	1,011.9	1,012.9	−2.0	89	73	81.2	+1.3	95	9	67	19	23	0	72	80	3.36	−3.1	1.34	13	8	.0	.0	7.6	ne.	25	n.	22	7	9	14	6.2	63
EAST GULF																																				
									74.4	−1.8								78	6.21	+1.4															5.1	
Atlanta [2]	1,173	33	72	975.3	1,015.9	−1.4	80	63	71.5	−1.3	91	9	52	26	26	14	60	73	3.60	+.6	1.84	5	0	.0	.0	8.3	ne.	28	e.	28	13	9	8	4.8	68
Macon [4]	370	79	87	1,002.7	1,015.9	−1.0	83	64	73.6	−1.2	93	9	54	26	30	3	62	71	1.63	−1.6	.95	6	2	.0	.0	5.7	e.	20	e.	26	10	8	12	5.9	69
Thomasville	273	48	----	1,006.1	1,015.9	−.4	85	67	75.8	−1.0	95	10	58	26	27	0	----	--	3.35	−1.5	1.57	7	1	.0	.0	----	------	----	------	--	3	13	14	----	--
Apalachicola	35	11	51	1,012.5	1,013.9	−1.7	83	71	77.0	−1.5	92	23	62	28	20	0	70	83	6.42	−1.7	2.37	12	5	.0	.0	8.9	ne.	30	se.	4	12	4	14	5.7	48
Pensacola [4]	56	54	79	1,012.2	1,013.9	−2.0	83	70	76.2	−1.8	92	23	61	27	22	1	67	78	12.60	+7.3	5.28	11	3	.0	.0	7.8	e.	38	se.	4	13	6	11	5.2	66
Anniston	618	6	32	997.3	1,016.6	−.3	83	60	71.2	−2.9	92	22	48	24	35	6	62	78	3.13	−.5	1.45	5	0	.0	.0	----	------	----	------	--	----	----	----	----	--
Birmingham [3]	700	5	63	991.2	1,015.9	−1.4	83	62	72.5	−.7	94	22	50	24	33	4	61	72	3.63	+.2	2.34	7	1	.0	.0	7.5	e.	37	e.	4	14	7	9	4.6	61
Mobile [4]	57	86	161	1,012.2	1,014.2	−1.4	84	68	75.9	−1.2	92	23	60	28	24	1	66	80	7.26	+2.3	3.47	11	0	.0	.0	7.8	e.	34	s.	4	7	14	9	5.6	52
Montgomery [4]	218	92	105	1,007.1	1,014.6	−2.0	84	66	75.0	−1.3	93	22	58	29	27	3	64	75	3.13	+.1	1.82	8	1	.0	.0	6.4	e.	20	se.	4	16	7	7	4.5	70
Meridian [4]	375	67	92	1,001.7	1,015.2	−2.1	82	63	72.6	−1.9	92	1	53	30	28	11	64	80	5.69	+2.7	2.51	5	1	.0	.0	5.2	ne.	20	ne.	4	14	6	10	4.8	61
Vicksburg [4]	247	82	102	1,005.8	1,014.9	−1.7	82	65	73.4	−2.9	92	8	50	25	28	18	63	82	1.55	−1.3	.60	7	2	.0	.0	7.8	n.	23	n.	27	14	8	8	4.3	67
New Orleans C. O	53	76	84	1,011.5	1,013.5	−2.1	83	70	76.8	−2.4	91	1	60	28	22	0	68	81	15.26	+10.2	6.78	13	3	.0	.0	7.3	ne.	34	ne.	4	11	7	12	5.5	54
New Orleans A. P. [3]	30	6	52	1,011.5	1,013.2	----	83	68	75.8	----	91	8	58	30	25	0	68	84	13.53	----	----	12	3	.0	.0	----	e.	----	------	--	13	6	11	5.1	--

See footnotes at end of table.

CLIMATOLOGICAL DATA FOR WEATHER BUREAU STATIONS FOR SEPTEMBER 1948—Continued

District and station	Elevation of instruments: Barometer above sea level [1]	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station	Pressure: Sea level	Pressure: Departure from normal	Temperature of the air: Averages: Mean maximum	Mean minimum	Mean	Departure from normal	Temperature of the air: Extremes: Highest	Date	Lowest	Date	Greatest daily range	Total heating degree days	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Departure from normal	Greatest in 24 hours	Days with 0.01 inch or more	Days with thunderstorms	Total snowfall (unmelted)	Snow, sleet, and ice on ground at end of month	Wind: Average hourly speed	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Character of day (sunrise to sunset), number of days: Clear	Partly cloudy	Cloudy	Average cloudiness, tenths (sunrise to sunset)	Possible sunshine
WEST GULF	Ft.	Ft.	Ft.	Mb.	Mb.	Mb.	°F	°F	°F.	°F.	°F		°F.		°F		°F.	%	In.	In.	In.			In.	In.	m. p. h.					0-3	4-7	8-10	0-10	%
Shreveport [2]	181	5	64	1,005.8	1,014.6	−1.3	89	65	77.6	−.5	99	6	53	30	35	0	62	70	2.40	−1.6															4.0	
Fort Smith [2]	463	6	30	999.0	1,014.9	−.7	88	60	76.9	−1.0	99	6	46	26	40	10	57	69	.41	−2.4	.37	3	1	0.0	0.0	8.5	n.	40	w.	8	20	6	4	3.4	84
Little Rock [2]	265	28	58	1,003.1	1,015.9	−.4	84	63	74.0	.0	98	8	54	30	31	10	62	66	.14	−2.8	.08	3	4	.0	.0	6.2	ne.	24	n.	28	17	11	2	3.5	84
Austin [2]	621	5	41	992.6	1,013.9	−.7	90	67	73.8	−.3	96	8	54	30	31	10	62	74	1.20	−2.0	.91	6	4	.0	.0	7.3	ne.	25	e.	19	15	9	6	4.2	73
Brownsville [2]	20	5	54	1,009.5	1,011.2	−1.3	88	72	78.4	+.1	101	5	53	30	37	0	62	66	1.24	−2.2	.99	5	1	.0	.0	9.1	n.	28	ne.	26	16	8	6	3.8	66
Corpus Christi [2]	44	6	33	1,012.2	1,012.9	−1.0	88	70	80.0	−.6	99	4	57	29	31	0	70	81	8.90	+3.1	5.44	10	4	.0	.0	8.9	se.	26	se.	8	13	8	9	4.9	70
Dallas [2]	488	34	45	996.3	1,014.6	−.6	90	66	79.3	+.7	100	4	54	28	34	0	70	82	6.64		4.47	6	0	.0	.0	9.5	ne.	29	w.	8	18	6	6	3.9	73
Fort Worth [2]	706	40	56	990.9	1,014.6	−.3	90	66	77.6	+.2	99	6	49	27	37	2	58	58	.07	−2.6	.07	2	1	.0	.0	8.7	ne.	27	s.	6	22	8	1	2.9	90
Galveston [4]	54	122	129	1,011.5	1,013.5	−1.4	82	74	78.0	+1.7	99	5	53	27	33	1	58	56	.19	−2.3	.19	2	1	.0	.0	9.4	e.	27	s.	6	21	6	3	3.0	86
Houston [4]	138	157	190	1,008.5	1,013.5	−1.4	87	70	78.5	−.5	96	5	57	28	27	0	66	78	.90	−3.2	.67	5	1	.0	.0	9.9	ne.	25	se.	16	13	7	10	5.6	61
Laredo [2]	418	10	38	997.6	1,012.2		91	70	80.6	−1.6	103	5	55	28	31	0	64	68	4.25	+1.0	1.40	10	5	.0	.0		ne.				13	11	6	4.5	
Palestine	510	64	72	997.0	1,014.6	−1.0	87	66	76.8	−.2	97	5	54	29	29	1	60	60	.36	−2.6	.33	3	1	.0	.0	6.6	ne.	23	s.	8	18	6	6	3.6	77
Port Arthur [4]	34	59	134	1,011.9	1,013.2	−1.7	85	70	77.6	−1.9	92	1	56	28	27	0	67	83	2.43	−2.4	2.03	8	2	.0	.0	12.7	ne.	33	se.	16	16	7	7	4.3	72
San Antonio [2]	794	6	51	990.2	1,013.9	−.3	88	67	77.7	−1.3	100	5	51	27	33	0	62	68	1.98	−1.1	1.18	8	3	.0	.0	8.3	ne.	34	se.	8	11	11	8	4.7	67
OHIO VALLEY AND TENNESSEE																																				
Chattanooga [2]	762	6	66	989.5	1,016.3	−1.3	83	60	69.2	+1.6	92	22	52	24	32	3	61	72	2.81	−.2															5.6	
Knoxville [2]	995	27	71	981.7	1,016.9	−1.1	82	60	71.5	+3.3	90	9	52	24	32	12	59	70	3.08	.0	1.32	8	3	.0	.0	6.0	n.	30	nw.	7	11	8	11	5.4	60
Memphis [2]	399	5	49	1,001.7	1,015.6	−1.0	84	62	71.5	+2.1	90	9	52	24	32	12	59	70	1.52	−1.2	.55	9	2	.0	.0	6.7	ne.	24	ne.	28	11	11	8	5.2	42
Nashville [2]	546	5	72	997.0	1,016.6	−1.4	83	61	73.0	+1.1	94	21	50	26	33	16	61	72	2.22	−.6	.91	7	2	.0	.0	7.0	n.	19	n.	25	18	4	8	4.1	74
Lexington [2]	989	4	58	982.4	1,018.3	.0	80	58	71.9	+.1	93	2	49	26	32	20	59	70	3.31	−.1	1.55	10	3	.0	.0	6.5	n.	26	s.	5	14	9	7	4.3	60
Louisville [2]	525	5	54	1,000.0	1,016.9	−1.1	82	59	69.0	+.5	92	20	46	24	36	46	56	69	2.14	−.9	.92	7	4	.0	.0		ne.				8	14	8	5.3	
Evansville [2]	431	6	40	1,001.4	1,016.9	−.4	81	59	70.4	+1.4	94	16	48	24	43	24	56	65	1.47	−1.3	1.05	5	2	.0	.0	6.7	ne.	20	ne.	25	8	13	9	5.4	62
Indianapolis [2]	823	5	54	988.2	1,017.3	−.3	78	56	69.9	+2.2	92	20	48	24	39	22	59	74	4.33	+1.0	1.60	7	2	.0	.0	7.2	ne.	27	ne.	25	11	9	10	5.3	72
Terre Haute [2]	575	4	36	996.6	1,017.3	.0	80	56	67.4	+2.0	90	19	46	23	35	52	56	71	3.03		1.48	9	7	.0	.0	8.6	sw.	25	w.	8	7	10	13	5.9	60
Cincinnati [4]	627	135	148	995.3	1,018.0	.0	82	61	68.4	+1.1	94	20	44	23	39	42	58	75	5.08	+1.5	2.72	9	6	.0	.0	7.7	ne.	34	w.	20	8	8	14	5.8	66
Columbus [4]	822	90	110	988.5	1,018.0	.0	79	58	71.5	+4.4	94	19	49	23	35	26	56	68	.70	−2.0	.46	7	2	.0	.0	4.3	ne.	14	ne.	23	7	12	11	5.8	57
Dayton [2]	1,003	6	55	982.1	1,018.0	.0	79	57	68.9	+2.4	92	17	45	23	31	45	55	70	2.25	−.3	1.07	7	4	.0	.0	7.6	s.	21	s.	11	7	14	9	5.6	69
Elkins [2]	1,947	5	45	950.6	1,019.3	.0	74	50	67.8	+1.9	90	19	44	23	34	55	54	68	1.67	−1.2	.99	10	3	.0	.0	8.8	ne.	26	w.	18	6	12	12	6.1	62
Parkersburg	637	77	84				79	58	68.4	+1.4	94	19	49	23	35	129	54	89	5.03	+1.9	2.08	8	5	.0	.0	4.5	n.	22	w.	21	3	13	14	6.8	56
Pittsburgh [2]	842	39	54	988.2	1,018.3	.0	76	56	68.3	+1.0	89	17	43	26	35	50	57	78	5.11	+2.4	1.37	7	5	.0	.0	5.5	se.	18	nw.	9	8	8	14	6.2	60
LOWER LAKES																																				
Buffalo [2]	768	34	96	990.5	1,018.6	+1.3	76	54	65.2	+2.9	92	5	39	22	34	93	53	75	1.92	−1.0															5.7	
Canton	448	10	61	1,001.7	1,017.6	+1.0	74	48	64.9	+3.3	87	6	30	16	39	175	50	74	5.74	+2.8	2.12	9	7	.0	.0	10.2	sw.	33	sw.	17	8	9	13	5.6	82
Oswego	335	71	85				72	55	61.4	+2.6	87	6	30	16	39	175	50	74	.84	−2.5	.30	6	3	.0	.0	5.2	w.	21	sw.	17	9	13	8	5.0	67
Rochester [2]	523	4	69	999.3	1,018.6	+1.0	75	53	63.6	+2.1	87	6	44	26	35	118			.86	−1.8	.22	9	4	.0	.0	7.1	se.	24	n.	20	11	10	9	5.0	58
Syracuse [2]	596	5	57	997.0	1,018.6	+.6	76	54	64.1	+1.7	91	5	40	22	35	114	53	78	1.54	−.9	.62	8	4	.0	.0	7.0	sw.	30	sw	17	9	9	12	5.6	66
Erie [4]	714	57	81	992.6	1,018.3	+.7	74	50	63.0	+2.7	89	13	34	25	45	135	54	81	1.02	−1.7	.56	5	5	.0	.0	6.6	sw.	25	w.	11	7	12	11	5.7	51
Cleveland [2]	762	27	54	990.5	1,018.0	.0	77	59	66.4	+2.8	86	5	45	25	20	67	54	80	1.01	−2.4	.46	7	4	.0	.0	6.8	se.	22	se.	29	6	11	13	5.8	37
Sandusky	629	5	67	994.9	1,018.0	.0	77	56	66.4	+2.6	89	17	40	26	32	75	55	72	2.49	−.8	1.09	8	3	.0	.0	8.2	s.	38	w.	19	5	9	16	6.2	48
Toledo [2]	629	5	47	994.9	1,018.0	.0	77	56	68.0	+2.7	91	19	48	27	29	44			1.90	−1.1	.82	9	2	.0	.0	7.4	ne.	20	nw.	20	9	13	8	5.2	60
Fort Wayne [2]	857	5	34	986.8	1,017.6	.0	79	55	66.6	+3.5	91	19	44	25	33	75	56	74	2.16	−.6	.96	9	4	.0	.0	9.2	sw.	26	nw.	20	7	9	14	6.2	59
Detroit [2]	730	5	77	992.2	1,018.6	+.6	76	56	67.0	+3.9	92	19	43	23	37	67	54	70	1.82	−1.2	.82	7	3	.0	.0	7.3	sw.	27	s.	6	6	10	14	6.2	64
UPPER LAKES									66.2	+3.8	88	19	44	22	29	74	55	71	1.79	−1.1	.54	8	7	.0	.0	7.5	ne.	23	nw.	10	6	11	13	6.0	54
Alpena	609	5	89	996.6	1,019.3	+2.0	71	53	64.0	+4.8	88	17	40	22	29	130	53	72	1.30	−2.0															4.8	
Escanaba	612	51	72	996.3	1,018.6	+2.0	71	53	62.0	+4.4	88	17	40	22	29	130	53	75	1.60	−2.0	.43	8	1	.0	.0	8.8	nw.	27	se.	16	11	10	9	5.0	72
Grand Rapids [4]	707	70	244	992.6	1,018.3	+1.0	78	57	62.2	+5.1	79	17	42	26	28	123	53	74	1.03	−2.3	.71	6	3	.0	.0	8.5	n.	34	s.	1	14	10	6	3.8	71
Lansing [4]	878	5	90	986.5	1,018.6	+1.0	77	54	67.4	+4.7	90	4	45	25	30	55	53	70	1.26	−2.3	.37	9	4	.0	.0	9.5	ne.	28	sw.	17	14	7	9	4.6	64
Marquette	734	44	73	991.2	1,018.6	+2.3	71	53	65.2	+3.5	89	12	41	25	33	98	52	68	1.62	−1.3	.66	10	2	.0	.0	8.2	sw.	22	se.	29	9	9	12	5.4	59
Sault Sainte Marie [2]	614	10	52	992.2	1,019.0	+2.1	71	48	62.0	+4.5	91	12	42	23	36	161	52	72	1.21	−2.0	.57	7	2	.0	.0	6.6	w.	26	sw.	12	16	7	7	4.0	67
Chicago [2]	673	5	38	993.6	1,017.6	+.3	78	58	67.8	+2.9	92	19	49	27	35	49	56	70	2.02	−1.5	1.37	9	5	.0	.0	7.8	nw.	24	nw.	13	11	10	9	4.9	70
Green Bay	617	5	32	995.6	1,018.3	+2.0	75	53	64.0	+3.6	91	12	36	27	36	124	53	70	2.38	−.8	1.37	9	1	.0	.0	7.4	ne.	29	s.	1	14	5	11	5.0	74
Milwaukee [2]	681	33	66	993.2	1,018.0	+1.1	75	57	66.4	+5.4	92	12	47	25	32	73	56	73	1.40	−2.1	.96	7	4	.0	.0	6.3	s.	24	se	1	10	12	8	4.9	69
Duluth [4]	1,133	5	47	976.6	1,018.3	+2.7	74	53	63.2	+8.1	91	12	43	9	34	137	49	72	1.24	−2.0	.40	8	4	.0	.0	11.0	sw.	33	sw.	17	16	7	7	4.5	59
NORTH DAKOTA																			.27	−3.0	.17	4	0	.0	.0	11.0	ne.	29	sw.	16	20	6	4	3.1	74
Fargo [2]	940	5	47	981.4	1,015.6	+.7	78	51	64.0	+7.0	95	2	40	9	39	97	50	54	.29	−1.3															4.8	
Bismarck [2]	1,677	5	41	955.0	1,014.6	−.3	81	49	64.7	+6.5	103	15	34	28	52	99	44	62	.85	−1.4	.36	6	3	.0	.0	12.0	s.	34	s.	4	12	10	8	4.7	67
Devils Lake	1,478	11	44	962.1	1,015.2	+.6	78	49	64.8	+7.5	97	3	36	30	43	118	44	52	.02	−1.2	.02	1	2	.0	.0	10.2	se.	33	se.	26	10	15	5	4.8	70
Williston	1,878	42	50	947.2	1,013.5	−.7	78	48	63.4	+7.5	97	3	30	9	47	121	41	52	.27	−1.4	.14	3	2	.0	.0	8.4	se.	24	s.	27	12	14	4	4.4	79
	1,878	42	50	947.2	1,013.5	−.7	78	48	63.2	+6.6	101	3	30	9	47	121	41	48	.02	−1.1	.01	2	1	.0	.0	6.6	se.	22	nw.	4	8	14	8	5.5	85

See footnotes at end of table.

CLIMATOLOGICAL DATA FOR WEATHER BUREAU STATIONS FOR SEPTEMBER 1948—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station	Pressure: Sea level	Pressure: Departure from normal	Temperature of the air: Averages: Mean maximum	Mean minimum	Mean	Departure from normal	Temperature of the air: Extremes: Highest	Date	Lowest	Date	Greatest daily range	Total heating degree days	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Departure from normal	Greatest in 24 hours	Days with 0.01 inch or more	Days with thunderstorms	Total snowfall (unmelted)	Snow, sleet, and ice on ground at end of month	Wind: Average hourly speed	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Character of day (sunrise to sunset), number of days: Clear	Partly cloudy	Cloudy	Average cloudiness, tenths (sunrise to sunset)	Possible sunshine
UPPER MISSISSIPPI																																				
	Ft.	Ft.	Ft.	Mb.	Mb.	Mb.	°F.	°F.	°F.	°F.	°F.		°F.		°F.		°F.	%	In.	In.	In.			In.	In.	m. p. h.					0-3	4-7	8-10	0-10	%
Minneapolis-St. Paul [3]	919	43	74	983.7	1,016.6	+1.4	80	56	68.6	+3.8	94	12	43	10	33	58	52	71	2.39	-1.3														4.4	
La Crosse [3]	672	5	29	991.5	1,017.3	+1.4	78	53	67.8	+6.4	93	15	38	27	38	58	52	61	1.04	-2.1	.79	4	2	0.0	0.0	9.0	se.	34	s.	16	18	8	4	3.4	75
Madison [3]	974	27	39	983.1	1,018.0	+1.4	79	53	66.4	+5.0	93	15	38	27	38	98	53	68	1.29	-2.7	.93	4	3	.0	.0	6.7	s.	26	sw.	17	13	13	4	4.2	77
Charles City	1,015	10	51	981.7	1,018.3	+2.0	79	54	66.4	+5.4	93	19	38	27	40	104	53	70	1.87	-1.8	.72	10	5	.0	.0	8.0	ne.	42	w.	19	14	7	9	4.7	70
Moline [3]	606	6	50	995.6	1,018.0	+1.1	79	56	67.6	+3.7	93	19	42	27	38	81			3.03	-.6	2.05	5	5	.0	.0	5.0	e.	19	s.	17	16	11	3	3.2	
Des Moines [4]	860	5	99	982.7	1,017.6	+1.7	82	59	70.4	+4.8	97	19	46	28	31	36	56	70	1.61	-2.1	.75	6	5	.0	.0	7.6	e.	28	sw.	17	13	12	5	4.1	
Dubuque	699	60	79	992.6	1,017.6	+1.0	79	58	68.2	+4.2	94	19	45	27	30	57	56	75	1.59	-2.4	.93	7	4	.0	.0	4.2	ne.	17	n.	19	13	8	9	4.6	
Burlington [3]	702	4	36	992.2	1,017.6	+.7	80	57	68.2	+1.8	94	19	46	9	33	56	58	80	4.76	+.3	2.36	6	6	.0	.0	8.1	ne.	34	nw.	20	15	5	10	4.6	
Cairo	357	5	99	1,003.7	1,016.3	-.3	81	63	72.1	-.4	92	2	53	24	28	15			4.70	+1.8	2.87	5	3	.0	.0	7.5	ne.	24	n.	8	12	9	9	5.0	72
Peoria [3]	609	7	26	995.6	1,017.6	+.3	80	58	69.0	+3.1	95	19	47	9	34	39	57	72	1.72	-2.3	.81	8	4	.0	.0	7.8	ne.	31	e.	1	13	7	10	4.9	70
Springfield, Ill. [4]	636	5	191	994.2	1,017.3	+.7	81	58	69.3	+4.5	94	19	46	24	35	43	58	72	.90	-2.7	.29	8	5	.0	.0	9.2	ne.	26	s.	1	11	9	10	5.1	64
St. Louis [4]	568	33	89	996.6	1,016.9	-.4	82	63	72.7	+2.3	95	20	51	26	27	16			2.50	-1.0	1.05	8	4	.0	.0	9.5	s.	28	n.	8	13	8	9		76
MISSOURI VALLEY																																				
Columbia, Mo. [4]	784	6	66	988.8	1,016.9	+.3	82	60	69.9	+3.8	93	20	49	25	31	31	58	69	2.58	-.5														3.7	
Kansas City [3]	963	38	76	982.4	1,016.6	+1.0	83	62	70.8	+1.4	95	20	48	26	28	13	56	76	2.52	-1.8	1.31	5	4	.0	.0	5.9	e.	18	ne.	28	18	7	5	3.9	
St. Joseph [3]	967	5	51	982.1	1,016.3	+.7	84	60	72.6	+3.7	95	20	48	26	28	13	56	65	1.88	-1.9	1.42	7	6	.0	.0	8.8	ne.	26	n.	8	20	6	4	3.0	
Springfield, Mo. [3]	1,324	5	50	1,004.1	1,016.9	+.3	81	58	71.6	+3.2	96	1	46	26	31	24	58	73	1.51	-2.4	.95	6	9	.0	.0	6.8	s.	26	sw.	17	17	8	5	3.6	
Topeka [4]	987	65	87	984.8	1,016.3	+.4	85	60	72.6	+3.9	99	1	47	27	35	20	57	72	1.36	-2.5	1.00	4	7	.0	.0	7.8	s.	23	sw.	17	17	9	4	3.3	
Lincoln [4]	1,189	6	81	973.9	1,016.3	+1.4	82	59	70.8	+4.4	100	1	43	28	33	42	56	70	5.17	+2.2	2.14	7	6	.0	.0	7.5	s.	26	s.	17	19	7	4	3.4	
Norfolk, Nebr. [3]	1,551	5	38	961.4	1,016.6	-----	81	55	68.0	+4.0	98	19	41	30	44	72	53	68	3.63	+.8	3.07	5	3	.0	.0	----	se.	--	------	--	17	8	5	3.7	
Omaha [3]	1,105	5	68	977.3	1,016.6	+1.0	82	58	70.0	+4.3	96	19	43	27	36	36	58	71	4.86	+1.6	3.62	5	6	.0	.0	8.6	s.	42	e.	1	16	9	5	3.8	
Valentine	2,598	46	54	924.1	1,014.9	-.3	80	53	67.0	+4.5	95	4	39	8	44	73	46	55	1.55	+.2	.91	7	6	.0	.0	9.2	s.	23	s.	4	17	5	8	4.0	
Sioux City [3]	1,138	5	40	975.3	1,014.6	-.6	84	55	69.2	+6.7	98	19	38	28	42	49	53	66	.31	-2.7	.31	1	2	.0	.0	8.7	e.	35	w.	17	15	9	6	3.8	
Huron [3]	1,301	5	41	969.2	1,015.6	+.4	80	53	66.4	+5.1	94	15	41	30	44	79	52	68	2.84	+1.3	2.54	7	5	.0	.0	12.0	se.	33	se.	4	15	5	10	4.7	
NORTHERN SLOPE																																				
Billings [3]	3,570	16	39	891.3	1,013.2	-2.7	78	50	60.8	+3.8	97	14	41	8	43	124	36	51	.50	-.7														4.7	
Butte	5,533	44	58	831.4	1,018.0	-----	69	33	63.8	+3.6	87	14	26	28	54	430	31	40	.40	----	.20	4	1	.0	.0	9.5	sw	28	nw	4	12	11	7	4.6	81
Glasgow	2,086	34	53	940.4	1,014.2	-----	79	48	50.6	-1.1	98	3	39	6	49	116	39	52	.63	-.2	.30	5	0	.6	.0	----	s	--	------	--	15	5	10	4.5	
Great Falls [3]	3,657	16	75	888.9	1,014.6	-----	72	48	63.4	+6.1	98	3	39	6	49	116	39	44	.38	-.7	.35	4	2	.0	.0	----	nw	--	------	--	10	11	9	5.0	
Havre	2,507	11	67	926.2	1,014.6	-.3	76	45	60.0	+2.1	92	14	35	24	38	199	36	44	.72	-.7	.41	5	1	T	.0	11.9	sw	42	sw	27	12	10	8	5.1	81
Helena [3]	4,124	5	43	874.7	1,015.9	+.7	73	41	60.2	+3.8	97	14	36	6	52	177	34	42	.14	-1.2	.08	4	0	.0	.0	7.2	w	26	w	11	10	12	8	5.1	79
Missoula [3]	3,263	4	32	902.8	1,016.3	.0	72	38	56.8	+1.4	94	14	31	28	52	255	36	50	.31	-.9	.28	3	1	.0	.0	7.3	w	32	nw	11	13	9	8	4.7	73
Kalispell	2,973	48	56	912.6	1,015.2	+.3	69	41	54.8	+1.4	92	2	27	24	50	307	36	54	.13	-1.1	.10	3	0	T	.0	6.3	nw	25	nw	22	13	8	9	4.9	62
Miles City [3]	2,371	5	28	930.6	1,013.9	-1.7	80	51	65.4	-----	101	15	40	30	51	89	40	44	.45	-----	.31	5	2	.0	.0	5.5	w	22	sw	22	12	10	8	4.7	72
Rapid City [3]	3,259	5	56	902.1	1,013.9	-1.7	81	52	66.6	+6.4	103	15	38	8	46	76	42	70	.59	-.6	.30	5	2	.0	.0	----	se	--	------	--	9	11	10	5.2	
Cheyenne [3]	6,094	22	40	815.4	1,013.9	-.7	77	47	61.7	+4.7	91	4	35	9	47	143	38	50	.54	-.7	.39	4	6	.0	.0	13.3	s	41	s	26	12	10	8	5.0	
Lander [3]	5,352	6	30	836.4	1,013.9	-1.0	77	48	62.4	+6.7	92	14	39	8	43	136	36	46	.73	-.2	.48	4	3	.0	.0	9.0	w	28	se	25	10	11	9	5.0	
Sheridan [3]	3,790	5	38	884.9	1,014.2	-1.4	78	47	62.8	+6.5	99	14	35	8	48	133	40	51	1.04	-.2	.88	6	3	.0	.0	7.6	sw	35	sw	1	14	10	6	4.0	
North Platte [4]	2,821	11	51	918.4	1,014.6	-.6	82	54	68.0	+5.9	94	12	37	29	43	60	50	64	.89	-.5	.60	4	5	.0	.0	8.3	se	34	se	23	15	12	3	3.7	
MIDDLE SLOPE																																				
Denver [4]	5,292	106	113	838.1	1,012.9	-1.7	81	56	71.9	+3.1	94	4	47	29	35	37	37	56	.50	-1.6														2.7	
Pueblo [3]	4,690	5	36	857.8	1,013.2	-.7	86	51	68.3	+5.4	97	1	37	29	48	41	37	40	.27	-.7	.20	3	2	.0	.0	7.2	s.	31	s.	25	17	7	6	4.0	
Concordia	1,392	50	58	966.8	1,015.9	+.7	84	60	68.2	+3.6	97	1	37	29	48	41	44	50	.17	-.6	.17	1	5	.0	.0	6.4	nw.	42	sw.	25	19	8	3	3.6	
Dodge City [3]	2,509	5	58	928.5	1,014.6	-.3	85	58	71.9	+3.6	100	1	45	29	34	33	53	59	1.19	-.8	.86	6	7	.0	.0	8.3	se.	26	sw.	17	22	7	1	2.2	
Wichita [3]	1,358	52	64	967.8	1,015.6	+.7	85	61	71.8	+2.4	98	1	44	28	35	34	52	58	.62	-1.3	.58	4	4	.0	.0	15.0	se.	35	s.	16	24	4	2	2.1	
Oklahoma City [4]	1,214	10	47	972.6	1,015.2	+.3	88	64	73.3	+2.7	96	1	47	26	31	19	54	59	1.05	-2.0	.94	4	6	.0	.0	13.0	s.	49	nw.	8	22	6	2	2.5	
Tulsa [3]	674	10	60	991.5	1,015.6	+.4	87	61	73.9	+1.0	96	7	47	27	32	9	58	68	T	-3.0	T	0	1	.0	.0	8.4	s.	29	n.	8	22	7	1	2.7	87
SOUTHERN SLOPE																																				
Abilene [3]	1,755	4	59	953.9	1,013.5	-.7	90	62	74.6	+.8	105	6	45	28	40	10	53	54	.73	-1.8														3.3	
Amarillo [3]	3,604	5	42	891.0	1,014.3	-.6	86	56	76.2	+2.4	99	2	42	27	36	39	49	52	.01	-2.7	.01	1	2	.0	.0	11.0	s.	38	n.	8	19	8	3	3.4	76
Del Rio	960	63	71	979.3	1,011.9	-1.0	88	69	70.6	+2.8	100	1	53	28	29	0	62	63	1.27	-1.0	1.02	4	4	.0	.0	12.5	s.	36	se.	2	22	5	3	2.7	86
Roswell	3,614	6	29	892.3	1,013.2	-.3	87	55	78.4	-.8	100	1	53	28	29	0	62	63	2.15	-.8	1.71	5	1	.0	.0	7.0	se.	34	ne.	4	13	10	7	4.6	68
Wichita Falls	1,030	4	49	978.3	1,014.2	-----	90	64	70.8	+.5	103	5	38	28	45	30	44	46	.21	-1.9	.19	2	4	.0	.0	7.1	se.	36	sw.	20	18	9	3	3.4	81
SOUTHERN PLATEAU																																				
El Paso [3]	3,916	35	85	886.2	1,010.8	-.4	88	64	77.1	+3.2	105	5	49	29	38	4	55	54	T	-2.8	T	0	2	.0	.0	----	--	--	------	--	24	4	2	2.4	
Albuquerque [3]	5,314	5	45	839.5	1,011.9	.0	85	58	76.0	+3.7	103	5	50	29	33	2	46	37	.50	-.5														2.8	
Flagstaff	6,907	34	48	703.8	1,016.6	+4.4	78	43	71.4	+3.5	98	3	44	29	36	13	41	38	.03	-1.2	.02	2	2	.0	.0	10.1	se.	38	nw.	6	19	5	6	3.4	81
Phoenix [4]	1,107	39	87	970.2	1,008.1	-.4	100	72	86.2	+3.5	112	3	62	23	35	0	49	32	T	-.8	T	0	2	.0	.0	7.9	se.	31	sw.	25	17	10	3	3.5	79
Tucson [3]	2,555	5	39	923.5	1,009.1	+.6	96	69	82.6	+2.9	107	3	60	22	36	0	50	35	1.11	-.1	.84	4	5	.0	.0	----	n.	--	------	--	16	11	3	3.5	
Yuma	142	9	54	1,001.0	1,008.1	+.3	103	70	86.2	+2.5	117	2	58	20	42	0	54	36	.02	-.3	.02	1	0	.0	.0	6.4	e.	26	n.	11	25	4	1	2.0	95
																										7.9	se.	29	ne.	11	19	9	2	2.7	86
																										5.0	sw.	17	s.	15	26	3	1	1.4	97

See footnotes at end of table.

CLIMATOLOGICAL DATA FOR WEATHER BUREAU STATIONS FOR SEPTEMBER 1948—Continued

District and station	Elevation of instruments: Barometer above sea level [1]	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station	Pressure: Sea level	Pressure: Departure from normal	Temperature of the air: Averages: Mean maximum	Mean minimum	Mean	Departure from normal	Temperature of the air: Extremes: Highest	Date	Lowest	Date	Greatest daily range	Total heating degree days	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Departure from normal	Greatest in 24 hours	Days with 0.01 inch or more	Days with thunderstorms	Total snowfall (unmelted)	Snow, sleet, and ice on ground at end of month	Wind: Average hourly speed	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Character of day (sunrise to sunset), number of days: Clear	Partly cloudy	Cloudy	Average cloudiness, tenths (sunrise to sunset)	Possible sunshine
MIDDLE PLATEAU	*Ft.*	*Ft.*	*Ft.*	*Mb.*	*Mb.*	*Mb.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*		°*F.*		°*F.*		°*F.*	%	*In.*	*In.*	*In.*			*In.*	*In.*	*m. p. h.*					*0-3*	*4-7*	*8-10*	*0-10*	%
Ely [2]	6,262	8	41	810.0	1,014.2	----	77	37	57.0	+4.6	90	2	16	26	52	247	26	32	.26	−.4	.26	2	1	0.0	0.0	11.6	s.	36	se.	17	22	6	2	2.3	93
Reno [2]	4,527	20	52	862.2	1,013.9	+.7	82	38	60.4	+2.4	97	10	26	27	56	163	34	42	.01	−.2	.01	1	0	T	.0	6.5	s.	34	w.	23	20	6	4	2.9	91
Winnemucca	4,339	5	56	867.6	1,013.9	−.7	81	41	61.0	+1.8	96	2	24	27	54	153	31	37	.04	−.4	.04	1	1	T	.0	7.0	ne.	29	sw.	14	19	7	4	3.1	80
Modena	5,473	10	46	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Salt Lake City [2]	4,357	32	58	866.9	1,012.5	−.7	81	51	66.0	+3.3	96	14	34	27	42	86	38	40	.59	−.4	.53	4	3	.0	.0	9.3	se.	29	nw.	19	21	8	1	2.6	80
Grand Junction [2]	4,602	5	26	860.1	1,013.2	−.3	85	54	69.6	+3.4	97	1	45	30	39	18	38	38	.46	−.5	.29	6	4	.0	.0	8.6	p.	34	se.	16	16	8	6	3.7	--
NORTHERN PLATEAU																																			
Baker [4]	3,471	36	54	895.7	1,015.9	−.4	73	40	59.4	−.2	91	10	29	23	48	275	40	54	.76	+.1														4.0	
Meacham	4,056	7	28	877.8	1,017.6	----	66	42	56.6	+.6	89	10	31	23	36	360	39	61	.25	−.5	.11	4	0	.0	.0	5.7	se.	29	sw.	14	17	7	6	3.7	85
Boise [2]	2,739	5	49	919.1	1,013.9	−.7	76	47	53.8	----	95	14	33	24	41	155	36	62	.62	----	.41	7	0	T	.0	----	nw.	----	----	----	14	8	8	4.3	--
Burley [2]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	43	.31	−.2	.16	3	0	.0	.0	9.1	se.	34	nw.	22	19	4	7	3.4	78
Lewiston	1,436	4	23	963.8	1,014.9	----	77	48	62.5	----	95	13	34	24	41	130	43	53	.49	----	.25	4	2	.0	.0	----	e.	----	----	----	12	12	6	4.2	--
Pocatello [2]	4,478	5	31	863.5	1,014.9	+.7	77	44	60.7	+1.4	94	13	32	28	52	165	33	43	1.39	+.6	.51	6	3	.0	.0	7.1	sw.	27	s.	14	20	5	5	3.1	79
Ellensburg [2]	1,735	5	58	953.9	1,015.9	----	73	43	57.8	−.2	91	10	30	23	46	237	42	60	1.17	+.7	1.06	3	1	.0	.0	----	nw.	----	----	----	16	10	4	4.0	--
Lacrosse	1,544	5	43	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Spokane [2]	1,929	6	51	946.8	1,015.9	+1.0	72	45	58.1	−1.1	91	13	33	23	40	236	38	52	1.46	+.6	.92	7	0	.0	.0	7.2	sw.	34	sw.	14	10	11	9	4.9	72
Walla Walla	991	57	65	979.7	1,015.2	+.3	76	52	63.6	−.2	97	13	39	24	38	131	----	----	.53	−.4	.33	4	0	.0	.0	4.3	s.	21	sw.	14	15	7	8	4.2	66
Yakima [2]	1,076	4	54	976.6	1,015.2	.0	77	42	59.5	−2.3	96	11	30	29	50	191	43	57	.64	+.1	.63	3	0	.0	.0	----	w.	----	----	----	13	10	7	4.3	--
NORTH PACIFIC COAST																																			
Kelso [2]	750	38	76	----	----	----	70	44	57.4	+.4	90	10	35	29	43	232	51	72	2.96	+1.0														5.0	--
North Head	211	5	55	1,008.5	1,015.9	−.7	63	53	58.0	+1.5	81	9	44	24	23	222	52	80	3.21	----	1.17	10	1	.0	.0	----	n.	----	----	----	8	11	11	5.5	59
Seattle [4]	125	90	321	1,011.9	1,016.6	.0	68	52	59.6	−.7	83	9	43	25	28	181	51	84	4.90	+1.9	1.21	11	1	.0	.0	13.0	n.	54	s.	14	10	8	12	5.2	57
Tacoma	194	172	201	1,009.5	1,016.3	−.3	66	49	57.4	+.1	77	10	37	25	23	230	----	78	3.07	+1.3	1.42	10	0	.0	.0	9.1	n.	36	s.	14	9	11	10	5.2	48
Tatoosh Island	86	5	61	1,012.9	1,015.9	−.7	60	50	55.2	+2.2	67	10	46	19	18	292	52	88	3.59	+1.5	1.33	10	1	.0	.0	7.6	n.	31	s.	14	8	12	10	5.2	45
Burns	4,162	35	47	873.7	1,015.2	----	73	38	55.7	+.1	91	10	24	23	48	284	34	48	5.34	+.7	1.14	14	1	.0	.0	12.3	s.	43	s.	2	9	7	14	6.1	--
Eugene [2]	433	4	35	1,002.4	1,015.9	----	75	46	60.4	----	98	10	37	30	50	178	48	69	1.15	+.3	.45	6	0	T	.0	----	n.	----	----	----	20	4	6	3.4	--
Medford [2]	1,329	29	58	968.2	1,015.6	+1.0	79	46	62.2	−1.3	102	9	35	25	51	158	46	62	2.52	----	1.02	8	1	.0	.0	----	n.	----	----	----	15	8	7	4.4	--
Portland, Oreg. [4]	154	68	106	1,010.8	1,016.3	+.4	73	53	63.0	+1.3	94	9	43	25	32	121	50	71	.30	−.4	.09	6	0	.0	.0	----	sw.	----	----	----	13	8	9	4.5	61
Rosebu g	510	45	76	----	----	----	76	49	62.5	−.4	98	9	41	30	49	135	----	----	3.86	+1.9	1.71	8	0	.0	.0	6.1	nw.	21	s.	14	10	11	9	5.1	57
MIDDLE PACIFIC COAST																			1.71	+.4	.77	8	0	.0	.0	4.0	n.	20	sw.	14	11	8	11	5.0	
Auburn [2]	1,651	4	58	----	----	----	----	----	65.2	+.4	----	----	----	----	----	----	----	64	.65	.0														3.5	--
Eureka	60	72	88	1,014.6	1,016.9	+.6	61	50	55.2	−.7	70	2	44	25	19	295	51	86	1.71	+.7	1.10	5	0	.0	.0	5.7	nw.	21	n.	28	10	10	10	5.4	51
Red Bluff [2]	353	5	26	999.7	1,012.2	----	89	59	74.2	+1.1	105	10	48	27	42	20	42	38	.70	−.1	.58	3	0	.0	.0	6.9	nw.	26	nw.	23	21	5	4	2.8	84
Sacramento [4]	66	92	115	1,009.8	1,012.2	+.3	86	56	71.2	+1.9	103	10	47	25	40	28	48	52	.10	−.3	.10	1	0	.0	.0	5.7	s.	17	s.	21	25	2	3	1.6	90
San Francisco [4]	115	112	132	1,008.5	1,014.2	+.7	67	53	60.0	−.9	83	13	50	13	33	154	51	78	.09	−.4	.09	1	0	.0	.0	9.2	w.	28	w.	24	13	11	6	4.3	74
SOUTH PACIFIC COAST																																			
Fresno [2]	327	5	34	999.7	1,011.5	+.3	92	56	71.2	+1.5	104	1	43	25	42	18	49	60	T	−.2														2.5	--
Los Angeles	338	236	263	----	----	----	84	59	73.8	+1.8	104	11	51	26	37	4	----	46	0	−.2	.0	0	0	.0	.0	5.2	nw.	23	nw.	23	25	5	0	1.6	98
San Diego [2]	87	20	55	1,008.5	1,011.9	.0	76	60	68.3	+.1	85	15	51	26	25	6	59	75	T	−.2	T	0	0	.0	.0	5.2	w.	17	w.	24	23	6	1	2.2	85
PANAMA CANAL																			T	−.1	T	0	0	.0	.0	5.5	nw.	16	sw.	23	17	10	3	3.6	74
BalboaHeights [4]	118	6	92	----	1,009.6	----	85	74	79.7	−.2	89	22	71	11	14	0	75	89	6.56	−1.4	2.22	21	11	.0	.0	4.6	s.	20	s.	19	0	13	17	7.8	--
Cristobal [4]	27	37	92	----	1,009.6	----	86	76	80.8	−.1	90	20	74	11	14	0	75	86	11.35	−1.3	2.55	27	9	.0	.0	5.5	s.	24	n.	7	0	9	21	7.8	--
ALASKA																																			
Anchorage [3]	132	6	44	1,000.3	1,005.4	----	55	36	45.6	−2.2	65	1	26	19	34	586	38	72	2.34	−.2	.68	12	0	.0	.0	5.4	n.	28	se.	16	2	7	21	7.9	--
Annette Island	113	5	53	1,008.5	1,012.5	----	55	46	50.8	−2.9	62	15	38	24	20	425	47	86	16.93	+7.7	3.92	20	0	.0	.0	----	se.	----	----	----	2	8	20	7.8	--
Barrow	29	5	27	1,011.2	1,011.2	----	30	20	24.6	−6.1	42	3	3	19	20	1,214	24	90	.88	+.4	.54	7	0	4.4	2.0	12.0	se.	37	se.	29	3	5	22	7.6	--
Bethel [2]	28	5	31	1,004.7	1,006.4	----	47	37	42.0	−3.1	61	6	27	22	19	693	38	85	3.08	+.1	.48	20	0	4.8	.0	10.5	nw.	63	s.	29	1	4	25	8.9	--
Cordova [2]	45	5	32	1,003.7	1,005.4	----	55	36	45.3	−2.4	67	2	27	27	35	591	42	88	20.26	+4.9	3.33	19	0	.0	.0	----	e.	27	se.	30	5	6	19	7.4	--
Fairbanks [2]	455	5	63	989.5	1,006.8	----	50	31	40.5	−3.1	67	8	16	19	34	735	36	79	.57	−.7	.21	10	0	2.1	.0	5.6	nw.	31	sw.	17	0	6	24	8.4	--
Galena	139	4	66	1,000.7	1,005.4	----	46	34	39.8	−2.0	64	8	22	19	26	755	31	69	2.15	+.4	.67	15	0	8.2	T	----	n.	40	e.	29	1	4	25	8.2	--
Gambell	32	5	32	1,007.5	1,008.5	----	41	35	38.3	−2.4	47	12	27	19	10	801	34	83	.92	−.9	----	8	----	.0	.0	16.0	n.	46	n.	16	0	4	26	9.0	--
Juneau [2]	80	6	30	1,008.5	1,009.5	----	55	42	48.2	−.4	66	13	27	28	31	503	42	80	11.51	+4.9	2.15	21	0	.0	.0	8.9	e.	38	se.	19	6	3	21	7.4	--
Kotzebue [2]	20	5	31	1,006.8	1,007.5	----	41	32	36.8	−3.6	56	8	19	22	21	851	32	79	.37	−.5	.13	9	0	.3	.0	15.2	se.	50	se.	20	7	4	19	7.1	--
McGrath [2]	341	5	31	993.7	1,006.4	----	48	32	39.9	−3.5	64	8	20	18	28	756	34	79	2.97	+.4	1.05	17	0	.4	.0	----	nw.	22	nw.	20	1	1	28	8.7	--
Nome [2]	22	10	75	1,006.4	1,007.1	----	44	31	37.4	−4.3	54	8	18	23	22	827	34	84	2.41	−.3	1.25	10	0	2.6	.0	13.6	n.	49	se.	28	7	3	20	7.2	--
Northway [2]	1,718	5	32	944.5	1,007.8	----	49	29	39.4	−2.4	64	5	16	23	33	772	32	74	.75	−.8	.46	6	0	4.3	T	----	nw.	----	----	----	2	5	23	7.9	--
HAWAII																																			
Honolulu [4]	38	86	98	1,014.6	1,015.9	----	83	74	78.7	+.5	85	18	70	23	13	0	66	66	1.41	+.1	.53	14	1	.9	.0	10.2	ne.	25	ne.	20	12	15	3	4.4	76

[1] Height of barometer cistern above mean sea level on January 1, 1900, or when station was first established since January 1, 1900. When station is moved to new location or airport, the pressure is reduced to the original elevation for homogeneity. These elevations do not represent the present station elevation in most cases.

[2] Data are from airport records. Pressures adjusted to original elevations according to note [1].

[3] Barometric, hygrometric, wind, character of day, and average cloudiness data from airport records; remainder from city office records.

[4] Barometric and hygrometric data from airport records; remainder from city office records.

[5] Barometric, temperature, degree day, and hygrometric data from airport; remainder from city office records.

[6] Bihourly hygrometric data.

NOTE.—Unless otherwise indicated, data in table are city office records.

SEVERE LOCAL STORMS FOR SEPTEMBER 1948

[The table hereunder contains such data as have been received concerning severe local storms that occurred during the month. A revised list will appear in the United States Meteorological Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Marathon and southwestern Lincoln Counties, Wis.	1	3:10-7:35 a. m.			$21,000	Electrical and wind.	Lightning struck and burned a large barn and contents 8 miles east of Wausau; killed 3 cows at Dancy, a horse in Marathon, and a cow in Scott; put 500 telephones out of service in Wausau. Wind blew down several power poles at Schofield.
Rhinelander, Wis.	1	Early morning.				Electrical	A radio station put out of service for several hours.
Florence, Wis.	1	do			20,000	do	A planing mill and warehouse struck by lightning and burned.
Valders, Wis.	1	Forenoon		1		Wind	Man killed when a high voltage wire was blown across wire fence he was repairing.
Southeastern Louisiana and Mississippi	3-4				800,000	Hurricane	Crossed coast line a short distance west of Grand Isle, La., with lowest pressure 29.24 inches at 3 a. m., Septembr 4, and highest wind from south-southeast, 63 m. p. h. at 2 a. m.; passed over sparsely settled areas; center reached New Orleans early the 4th, with lowest pressure 29.21 inches from 6:15 to 6:20 a. m., and highest winds 64 m. p. h. at Huey Long Bridge at 4:50 a. m., and 78 m. p. h. from north-northeast at Moisant Airport at 5:30 a. m. (the center of the hurricane passing over neither of these 2 points); continued with decreasing intensity, passing over Picayune, Purvis, and Hattiesburg, Miss., reaching Hattiesburg at 2 p. m. on the 4th when the lowest pressure was 29.67 inches, with highest winds 40 m. p. h. from northeast; thereafter it decreased steadily in intensity, but the circulation was maintained as it passed near Memphis, Tenn., and Cairo, Ill., reaching Lafayette, Ind., at 6 p. m. on the 6th. In section along Mississippi River below New Orleans, fall truck was inundated by heavy rains and high tides, and orange crop suffered considerable damage. In the region north of Lake Pontchartrain, fall bean crop destroyed by heavy rains and high winds; pecan and tung nut crops in this area and in southeastern Mississippi suffered considerable damage; possibly the heaviest damage to pecans. Sugarcane and corn blown down by high winds, aided by torrential rain in Terrebonne, La Fourche, Jefferson, and St. Charles Parishes. In Orleans Parish, including New Orleans, damage confined to small boats, signs, trees, and power and communications lines with damage estimated at $100,000. Greatest damage occurred off Grand Isle, when oil drilling rigs and equipment in the Gulf of Mexico wer demolished by heavy seas.
Alabama	3-4				88,000	do	Damage to property and crops by hurricane mentioned above.
Pensacola, Fla.	3-4				12,000	do	Pile driver, privately owned, sunk at Naval Air Station. An extreme wind velocity of 44 m. p. h, from southeast at 8:05 a. m, on 4th.
Havana, Fla.	4	Early afternoon.	70	2	250,000	Tornado	Storm cloud resembling a "giant ice cream cone," first struck 1½ miles south of Havana, then skipped to northwest portion of town. Destroyed 8 homes and 9 tobacco barns, and leveled trees and wire lines; no tobacco in barns destroyed. 12 persons hospitalized; no serious injuries. Storm apparently continued its north-northwestward course into Georgia.
Grady County (southwest and central), Ga.	4	1:15-2 p. m.	50-75	0	75,000	do	One or more small tornadoes moved northward along earth's surface for several miles, lifting north of Whigham. Several different areas affected. Damage to pecans, peanuts, and other crops, $18,000; to numerous homes and other buildings, $55,000; to stored feedstuff $1,500; to poultry, $500, Numerous trees and power and telephone lines also blown down.
Fernandina, Fla.	4	2:51-3:04 p. m.		0	0	Waterspout and tornado.	Waterspout moved southward along beach for about 2 miles; part of course over unoccupied land. "Funnel" lifted and re-formed several times.
Northwood, Worth County, Iowa.	5	A. m.				Hail	Hailstones of unusual size reported southwest of Northwood; one was 14 inches around longest distance and 12 inches around the shortest. Some corn stripped, but hail so scattered that damage was not serious.
Milan (vicinity of), Minn.	5	P. m.			9,000	Electrical	2 barns destroyed by lightning fire; some livestock and poultry perished.
International Falls, Minn.	5	P. m.			6,000	Rain	Many basements flooded; secondary roads rutted in places; crops ready for harvest damaged.
South Carolina, central portion.	6	6 a. m.-2 p. m.		1	350,000	do	Heavy rains, ranging up to 10 inches in 6 hours, caused many wash-outs and beat down crops. A wash-out resulted in train being derailed near Blairs, killing 1 person, injuring another; approximately $315,000 damage in the neighborhood. Some damage to bridges and roads in other areas, especially near Orangeburg and Newberry.
McClave, Colo.	6	4 p. m.	[1] 14¼		750,000	Hail	Hailstones some 9 inches in circumference destroyed alfalfa, maize, and corn crops, killed several thousand chickens and turkeys, injured livestock, broke windows, and damaged roofs of buildings and automobiles; $12,000 damage to airplanes and buildings at airport.
Morton County (Richfield to Elkhart), Kans.	6	9-9:30 p. m.	[1] 1		12,000	do	Local, over a strip 15 miles long. Near Richfield hail piled in drifts like snow; damaged windows, roofs, and maize.
Richmond, Va.	6	P. m.			1,000	Wind	Large tent at fair grounds toppled; exhibits damaged.
Tidewater sections, Virginia.	6-7					Wind and high tides.	Low sections of Norfolk and Portsmouth flooded; ferry service between the 2 cities interrupted. Sea wall at Virginia Beach damaged by heavy surf which knocked out several concrete breakwater slabs.
McLeansboro, Ill.	8	4:50 p. m.	440		6,200	Wind, rain, and electrical.	Many trees damaged, a few uprooted. Several roofs damaged. A large barn burned by lightning fire. 2 people injured when car went out of control.
Baltimore, Md.	8	6:30 p. m.			10,000	Wind, rain, and thunderstorm.	Storm, described by residents of east and northeast Baltimore as a "violent twister," hit that part of city. Strong winds ripped off roofs, blew in windows, and uprooted trees. 1 large plate glass show window, estimated worth $3,500, blown into highway. Considerable damage by heavy rain.

See footnote at end of table.

SEVERE LOCAL STORMS FOR SEPTEMBER 1948—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Goodwell (vicinity), Texas County, Okla.	8	9:30 p. m.				Hail and rain	Hail size of marbles to golf balls. Storm moved southeastward and caused considerable damage in spots to sorghum grains in fields.
Bloomsburg and vicinity, Pa.	9	Night			20,000	Electrical and wind	Lightning killed 10 farm animals and destroyed a barn. Trees 50 feet high and over a foot in diameter uprooted by high winds.
St. Augustine, Fla.	11	8 a. m.		0	0	Waterspout	Observed a short distance northeast of St. Augustine, moving northeastward out to sea.
Phoenix, Ariz.	11	5:10–7:50 p. m.			10,000	Wind and electrical	Local windstorm ripped off several roofs, and uprooted trees. 1 person injured when huge limb fell on auto, caving in top. Plate glass windows smashed by strong gusts. Many telephone and power lines put out of service by falling trees and branches. Pumping station tower collapsed after being struck by lightning.
Pinellas Point, Fla.	12			1		Electrical	Boy killed by lightning while playing on beach; 2 companions shocked also.
Seattle, Wash.	14–15				5,000	Wind	Maximum wind velocity of 36 m. p. h. at 5:56 p. m., at the City Weather Bureau Office, and gusts up to 47 m. p. h. at Boeing Field. A frail housing project apartment unroofed; trees uprooted with consequent damage to parked automobiles.
Washington, eastern counties.	14–15			1		Wind and dust	Duststorms eroded freshly planted grain in eastern wheat belt, especially in Douglas and Okanogan Counties; considerable damage to telephone and telegraph lines. Damage believed not heavy. 1 death at Colfax when dust blinded drivers of cars, resulting in collision.
Brown County, Wis.	15	5:45–6:30 a. m.				Electrical	Lightning knocked out power and light service in large part of De Pere; put county police radio transmitter at Green Bay out of service for several hours; and caused burning of historic church at New Franken.
Francis Creek, Wis.	15	A. m.			30,000	do	Cheese company warehouse and 15 to 20 tons of cheese destroyed by lightning fire.
Beloit (2 miles east), Mitchell County, Kans.	18	5 p. m.	[1] 1		8,000	Wind	1 large barn and smaller buildings destroyed.
Twin Falls, Idaho	18	3:30 p. m.				Rain	Basements flooded; some damage to hydroelectric power plant at Shoshone Falls; damage to alfalfa and beans in vicinity. 1.84 inches of rain in 2 hours at Bureau of Entomology station.
Boston and vicinity, Mass.	18	4–5 p. m.				Electrical and wind	Lightning struck at many widely scattered points; shattered chimneys broke electric light and power wires, and felled trees. Many small craft driven ashore or overturned by high winds and seas.
Ohio, entire State	19	Intervals during day and evening.		2		Wind, rain, and electrical.	Trees and wires damaged by wind and lightning. Roads flooded by heavy rains. 2 men killed by lightning on golf course at Akron. 4 houses damaged by falling trees at Celina. 2 barns destroyed by fire, apparently started by lightning. Tent blown down at fair grounds in Delaware, damaging merchandise on display.
St. Peter, Minn.	19	4:15 p. m.			45,000	Electrical	Several places struck by lightning; 1 building burned.
Janesville, Wis.	19–20	10:30 p. m.–12:45 a. m.			19,500	Electrical and rain	Upper 170 feet of WCLO–AM and WCLO–FM 281-foot radio tower, together with antennas, broke and fell to ground; estimated loss, $15,000. A section of roof of store and apartment ripped off. Many telephone and electric wires broken by falling limbs and trees and several highways blocked; 1 injury. Damage to merchandise by rain, $3,000.
South Bend, Ind.	20	3 a. m.			20,000	Wind and rain	Large tent blown down; contents damaged by rain.
Creston, Union County, Iowa.	20	1:50 p. m.				Wind	Heavy wind and rainstorm from west. Iowa Southern Utilities measured wind at 65 m. p. h. Heaviest damage suffered by Iowa Southern Utilities and Creston Mutual Telephone Company: lines ripped apart by winds and falling trees. Trees blocked nearly every street.
Iowa, southern portion	20	Afternoon and evening.				Wind and electrical	Strong winds occurred in connection with squall line that formed in central Iowa. At Burlington storm reached maximum intensity at 6 p. m., lifting roof off exhibit barn at Des Moines County fairgrounds and damaging other buildings. At Des Moines, 2 women stunned by lightning bolt. Numerous reports of wind damage to barns and small buildings in vicinity of Osceola.
Seaton, Ill.	20					Electrical	1 woman injured when her home was struck by lightning.
Homestead, Fla.	21			0	4,000	Tornado	Occurred in northeast sector of hurricane. Damage confined to destruction of farmhouse and tumbling 1½-ton truck along ground.
Scotts Bluff County, Nebr.	22	7–9 p. m.			520,000	Hail	Storm from northwest. 100 percent loss to standing beans in North Sunflower Community; 75 percent loss on windrowed and bunched beans in same area, some of which was caused by flooding. 10- to 80-percent loss on standing beans in upper Gering Valley. Probably a total of 80,000 bags of beans lost in county. Loss to beans, $500,000; and to hay, mostly alfalfa, $20,000.
Minneapolis, Ottawa County, Kans.	23	9:30 p. m.	[1] 3			do	Path 12 to 14 miles long. Some hailstones an inch in diameter.
Saline County (northwestern part), Kans.	23–24	10 p. m.–2 a. m.			100,000	do	Accompanied by torrential rain and high winds. Some hailstones as large as baseballs. Roofs and window glass severely damaged, and many small animals killed by hailstones.
Cuba and vicinity, Republic County, Kans.	24	3–5 a. m.	[1] 3			do	Path 8 miles long. Some hailstones 1½ inches in diameter. Many windows broken and roofs damaged.
Continental, Ariz.	26	Evening			6,500	Flash flood	Heavy rains, accompanying thunderstorm, brought flash flood down a canyon 7 miles south of Continental. 1 reinforced concrete bridge culvert completely washed out and destroyed. A 200-foot embankment washed out, and 500 square yards of asphaltic concrete pavement destroyed.

[1] Miles instead of yards.

SOLAR RADIATION DATA FOR SEPTEMBER 1948

[Solar Radiation Investigation Section, I. F. HAND, in Charge]

Explanation of Tables 1 and 2 and references to descriptions of instruments, stations, and methods of observation, and to summaries of data, are given in the MONTHLY WEATHER REVIEW, vol. 72, No. 1, January 1944, p. 43. A list of pyrheliometric stations is given on page 45 of that issue. An explanation of the formula used in computing the air mass values for each station listed in table 1 appears in vol. 75, No. 3, March 1947, p. 47.

TABLE 1.—*Solar radiaton intensities during September 1948*

[Gram calories per minute per square centimeter of normal surface]

MADISON, WIS.

Date	Sun's zenith distance									Vapor pressure	
	A. M.				0.0°	P. M.					
	78.7°	75.7°	70.7°	60.0°		60.0°	70.7°	75.7°	78.7°	7:30 a. m.[1]	1:30 p. m.[1]
	Air mass										
	4.81	3.84	2.88	1.92	*0.96	1.92	2.88	3.84	4.81		
September	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mb.*	*mb.*
3			0.90	1.06	1.28					12.7	15.3
4			.79	.96	1.27					14.2	15.8
9				1.21	1.37					10.6	10.6
10				1.25	1.38					9.8	10.2
11					1.32					12.3	14.8
13				1.04	1.36					15.3	14.2
14				1.13						11.8	11.8
15			.70	.88	1.32					11.4	16.5
18			.54	.73	1.24					19.0	21.1
23			.92	1.16	1.46					9.1	10.6
25			.88	1.02	1.36	1.18	.96			9.1	9.4
27				1.04	1.42	1.07	.87			7.8	9.1
28			.94	1.16	1.37	1.08				8.1	9.1
Means			.81	1.05	1.35	1.07	(.92)				
Departures			−.15	−.08	−.01	−.08	−.10				

LINCOLN, NEBR.

	Air mass										
	4.77	3.81	2.86	1.91	*0.95	1.91	2.86	3.81	4.77		
September	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mb.*	*mb.*
1			0.75	0.92	1.20					22.6	21.8
3				1.01	1.28	0.99	0.77			19.6	21.8
4				.99	1.22	1.03				19.0	20.4
8					1.40	1.17	.99	0.86	0.77	13.7	11.0
9				1.09	1.36					11.4	12.3
11			.99	1.17	1.32					14.6	19.0
13					1.20	1.01	.79	.62	.48	14.2	16.4
14	0.54	0.68	.82	1.01	1.24	1.06	.86	.73	.62	15.8	17.7
15		.82	.94	1.12	1.32	1.10	.92	.82	.69	15.8	14.6
16	.58	.69	.82	1.01	1.22					16.4	16.4
21					1.30	1.14	.88	.84	.71	17.7	18.3
25					1.33	1.14	.97	.84	.75	11.0	10.6
27	.68	.79	.88	1.09	1.32	1.14	.94	.84		8.4	11.4
28	.64	.77	.92	1.07	1.31	1.12	.97	.84	.62	8.4	10.2
29				1.16	1.34	1.17	.99	.84	.71	8.4	10.6
30	.68	.79	.94	1.09	1.28					8.4	9.4
Means	.62	.76	.88	1.06	1.29	1.10	.91	.80	.67		
Departures	−.11	−.08	−.09	−.08	−.11	−.05	−.06	−.03	−.05		

TABLE MOUNTAIN, CALIF.

	Air mass										
	3.76	3.01	2.26	1.51	*0.75	1.51	2.26	3.01	3.76		
September	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mb.*	*mb.*
2				1.28							
3				1.32							
6				1.43							
7				1.41							
8				1.40							
12				1.35							
19				1.48							
20				1.49							
22				1.50							
23	1.14	1.21	1.32	1.44							
26				1.46							
27				1.47							
30				1.41							
Means	(1.14)	(1.21)	(1.32)	1.42							
Departures	0	−.01	0	+.02							

BOSTON, MASS.

	Air mass										
	4.96	3.96	2.97	1.98	*0.99	1.98	2.97	3.96	4.96		
September	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mb.*	*mb.*
1	0.84	1.03	1.17	1.25						10.6	9.4
3	.48	.65	.77	.67						14.8	14.2
13	.53	.63	.82	.96						19.0	20.4
15			.89	1.08						9.1	6.4
16		.90	1.03	1.12						6.6	9.1
17	.56	.67	.79	.90						7.4	11.0
21		1.00								10.6	7.2
22		1.01	1.10	1.22						7.2	9.1
23		.74	.83	1.13						9.4	10.6
27			.94	1.00						9.8	12.3
28				1.05						10.6	12.3
29	.60	.70	.76	.83						13.2	15.3
Means	.60	.81	.91	1.02							
Departures	+.04	+.07	+.01	+.01							

BLUE HILL, MASS.

	Air mass										
	4.86	3.89	2.92	1.94	*0.97	1.94	2.92	3.89	4.86		
September	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mb.*	*mb.*
1	0.91	1.01	1.13	1.29	1.50	1.27	1.11	0.98	0.84	10.7	10.0
3	.47	.61	.73	.92			.51	.41	.32	13.3	19.7
5	.32	.41	.57	.77		.68	.58	.43	.37	18.9	18.6
6	.29	.40	.51	.74		.62	.53	.40	.32	19.8	17.1
7	.39	.47	.58	.90		1.01	.84	.67	.56	14.8	12.1
8	.55	.69	.77	.95		1.04	.81	.70	.58	18.2	17.2
9	.55	.64	.70	.92						10.5	17.1
12	.49	.57	.72	1.05			.63	.49	.39	13.8	13.8
13	.54	.62	.75	.93			.69	.53	.40	19.1	17.9
14						1.23	1.06	.90	.80	12.9	9.7
15			1.12	1.24						8.4	7.9
16	.97	1.07	1.15	1.27		1.24		.99	.87	6.9	6.8
17	.60	.72	.90	1.09						9.1	7.3
21	.94	1.01	1.14							11.0	8.2
22	1.00	1.08	1.19	1.34						6.9	7.9
23	.91	1.01	1.12							9.4	10.4
24						1.21	1.07	.98	.88	9.2	8.8
25	.94	1.03	1.11	1.17		1.35	1.20	1.09	.98	8.6	8.4
26	.88	.98	1.12	1.26		1.12	.92	.80	.71	9.1	9.8
27	.90	1.03	1.15	1.27		1.13	.99	.87	.76	9.3	8.8
28	.74	.83	.95	1.13		1.01	.86	.77	.70	10.2	11.0
29	.65	.76	.85	1.04		1.12	.91	.75	.60	13.0	10.1
30	.44	.54	.67							13.2	12.6
Means	.67	.77	.90	1.07	1.50	1.08	.85	.74	.63		
Departures	−.08	−.09	−.08	−.05	+.12	−.04	−.07	−.04	−.03		

* Extrapolated.

[1] 75th meridian time.

TABLE 2.—*Daily totals and weekly means of solar radiation (direct + diffuse) received on a horizontal surface*

[Gram calories per square centimeter]

Date	Washington, D. C.	Madison, Wis.	Lincoln, Nebr.	New York, N. Y.	Fresno, Calif.	Fairbanks, Alaska	Columbia, Mo.	Boston, Mass.	Nashville, Tenn.	Twin Falls, Idaho	La Jolla, Calif.	Riverside, Calif.	Blue Hill, Mass.	Newport, R. I.	Salt Lake City, Utah	Put-in-Bay, Ohio	State College, Pa.	Davis, Calif.	Toronto, Canada	Ithaca, N. Y.	Boulder, Colo.	East Wareham, Mass.	Honolulu, T. H.	Pearl Harbor, T. H.	East Lansing, Mich.	Summit, Mont.	Soda Springs, Calif.	Grand Lake, Colo.
1948	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Sept. 3	509	547	556	424	606	-----	430	305	338	531	445	577	422	555	562	464	454	572	365	301	-----	553	685	648	398	502	661	580
Sept. 4	386	526	565	293	561	-----	537	242	180	537	319	581	295	463	531	482	433	554	447	288	-----	468	692	619	433	461	578	626
Sept. 5	368	469	561	314	581	-----	-----	442	300	532	470	590	473	491	563	401	427	539	442	332	-----	433	633	573	330	357	623	522
Sept. 6	372	369	309	455	570	-----	570	384	370	531	536	588	429	510	560	407	247	537	393	322	-----	482	578	466	210	428	608	398
Sept. 7	230	485	98	257	572	-----	579	441	256	535	-----	-----	496	536	572	290	274	527	257	258	-----	502	625	550	195	557	607	383
Sept. 8	376	118	557	210	579	-----	119	477	414	527	424	-----	506	486	555	439	198	527	420	187	-----	500	632	520	223	556	606	630
Sept. 9	442	462	444	346	566	-----	623	392	102	519	400	-----	456	482	543	283	319	522	215	168	-----	470	700	653	428	486	566	568
Means	383	425	442	328	576	-----	476	383	280	530	432	-----	440	503	555	395	336	540	363	265	-----	487	649	576	317	478	607	530
Departures	−8	+44	+3	−33	+12	-----	−15	+10	−105	+30	−47	-----	+54	+80	+23	−24	−22	−4	−9	−101	-----	+85	+9	+1	−32	−19	+2	+2
Sept. 10	18	567	482	117	534	-----	582	306	464	514	288	-----	331	365	534	447	190	516	308	145	-----	321	676	652	362	539	586	616
Sept. 11	479	520	553	502	539	-----	536	310	538	505	502	-----	335	314	530	430	376	500	282	234	452	280	599	652	323	512	579	537
Sept. 12	506	498	509	484	557	-----	593	401	559	504	330	-----	464	492	544	516	494	518	434	288	508	462	694	620	399	403	576	519
Sept. 13	492	521	513	383	540	-----	567	417	275	475	408	-----	436	472	524	455	476	494	439	314	490	445	694	613	367	486	577	588
Sept. 14	396	491	526	488	556	-----	555	422	499	459	428	-----	463	498	529	529	539	517	382	353	-----	482	706	639	391	474	573	489
Sept. 15	496	483	540	514	564	-----	568	417	534	365	451	-----	494	484	300	265	442	510	335	350	406	405	696	577	72	449	565	522
Sept. 16	330	456	453	490	509	-----	543	474	519	366	452	-----	508	551	300	463	486	165	411	340	217	512	682	550	324	346	440	184
Means	388	505	511	426	543	-----	563	392	484	456	408	-----	433	454	466	443	429	460	370	289	415	415	678	615	320	458	556	568
Departures	+7	+159	+90	+66	+12	-----	+117	+63	+98	−16	−39	-----	+63	+68	−14	+53	+22	−38	+24	−52	−10	+47	+15	+23	+32	+30	+6	+8
Sept. 17	360	331	470	260	488	-----	541	306	476	234	263	463	400	444	468	404	395	247	317	243	317	427	637	514	268	220	415	334
Sept. 18	358	443	495	378	525	-----	524	313	396	246	254	436	346	338	347	222	291	392	159	186	380	332	649	584	200	156	380	530
Sept. 19	212	409	474	346	564	-----	416	366	429	179	511	483	279	426	241	398	289	531	263	111	256	442	678	610	294	484	587	266
Sept. 20	331	91	225	178	544	-----	476	66	448	466	475	371	49	69	496	187	124	527	283	104	397	44	686	583	92	353	595	500
Sept. 21	18	51	493	419	513	-----	509	455	488	465	467	324	471	503	505	107	195	515	348	234	491	459	667	603	178	426	555	573
Sept. 22	336	360	370	491	549	-----	130	425	426	426	471	469	492	519	490	400	394	428	452	173	402	470	681	544	327	313	521	429
Sept. 23	388	429	295	338	546	-----	548	212	479	402	291	451	321	367	472	366	372	512	156	158	-----	468	532	487	170	263	309	552
Means	286	302	403	344	533	-----	449	306	449	345	390	428	337	381	431	298	294	450	283	173	374	378	647	561	218	316	480	455
Departures	−77	−52	−4	+16	+41	-----	+17	+25	+78	−80	−12	−28	−14	+29	−5	−44	−38	−31	−37	−180	−60	+55	+20	+2	−79	−10	−10	+1
Sept. 24	126	327	132	283	536	-----	551	326	464	120	352	329	342	286	446	287	181	521	294	94	-----	173	550	448	115	95	282	542
Sept. 25	380	460	498	424	557	72	532	436	471	90	466	450	433	480	287	499	343	470	432	300	-----	467	644	563	299	100	368	511
Sept. 26	443	461	485	464	552	85	537	391	271	402	473	455	436	485	475	497	494	498	418	300	-----	445	553	566	382	311	497	354
Sept. 27	398	451	486	448	539	183	509	358	336	448	450	438	423	480	482	478	488	505	379	319	233	438	430	408	350	86	529	351
Sept. 28	162	445	478	363	520	119	389	409	106	450	464	433	417	450	348	359	379	487	384	307	412	402	372	391	384	450	519	370
Sept. 29	160	184	478	379	504	52	84	356	239	436	368	441	419	433	422	202	213	479	289	234	375	412	589	552	170	141	473	422
Sept. 30	82	102	424	100	494	83	210	172	276	421	317	439	262	317	439	292	255	424	202	142	145	339	614	575	115	322	435	237
Means	250	347	426	352	529	-----	400	354	309	338	413	426	390	419	414	373	336	484	343	242	-----	382	536	500	245	215	443	398
Departures	−94	+46	+68	+41	+67	-----	+60	+55	−28	−88	+38	−17	+47	+78	+9	+37	−8	+23	+21	−77	-----	+31	−32	−25	−28	−34	−12	−19

ACCUMULATED Ddepartures ON SEPTEMBER 30, 1948

	Washington, D. C.	Madison, Wis.	Lincoln, Nebr.	New York, N. Y.	Fresno, Calif.	Fairbanks, Alaska	Columbia, Mo.	Boston, Mass.	Nashville, Tenn.	Twin Falls, Idaho	La Jolla, Calif.	Riverside, Calif.	Blue Hill, Mass.	Newport, R. I.	Salt Lake City, Utah	Put-in-Bay, Ohio	State College, Pa.	Davis, Calif.	Toronto, Canada	Ithaca, N. Y.	Boulder, Colo.	East Wareham, Mass.	Honolulu, T. H.	Pearl Harbor, T. H.	East Lansing, Mich.	Summit, Mont.	Soda Springs, Calif.	Grand Lake, Colo.
	− 3724	+ 6560	+ 6293	− 6041	+ 12152	-----	-----	(− 3710)	-----	(− 1981	− 3815)	-----	(− 3899	+ 385	− 511)	-----	(− 2380	− 4018	+ 1932	− 22071)	-----	(− 1365)	-----	-----	(− 602)	-----	-----	-----

TABLE 3.—*Daily totals and weekly means of solar and sky radiation plus the radiation reflected from the ground, as received on a vertical surface facing south at Blue Hill, Mass., during September 1948*

Date	3	4	5	6	7	8	9	Mean	10	11	12	13	14	15	16	Mean
Gm cal/cm ²	296	-----	360	334	386	401	362	357	250	236	383	368	390	410	432	353

Date	17	18	19	20	21	22	23	Mean	24	25	26	27	28	29	30	Mean
Gm cal/cm ²	327	291	275	36	443	464	293	304	308	471	477	441	443	453	233	404

U. S. GOVERNMENT PRINTING OFFICE: 1948

Chart I. Departure (°F.) of the Mean Temperature from the Normal and Weather Types

Chart I. Departure (°F.) of the Mean Temperature from the Normal, and Wind Roses for Selected Stations, September 1948

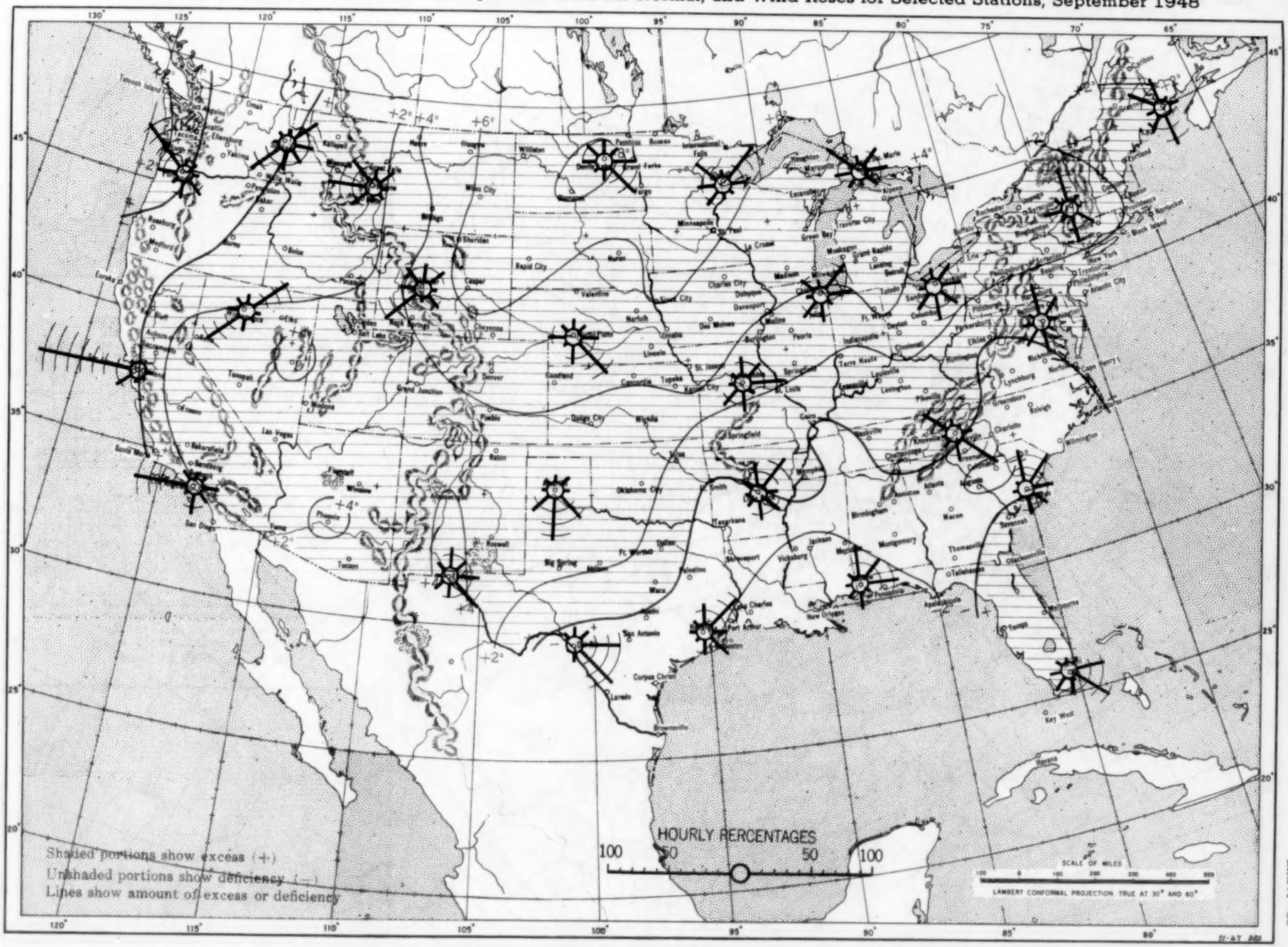
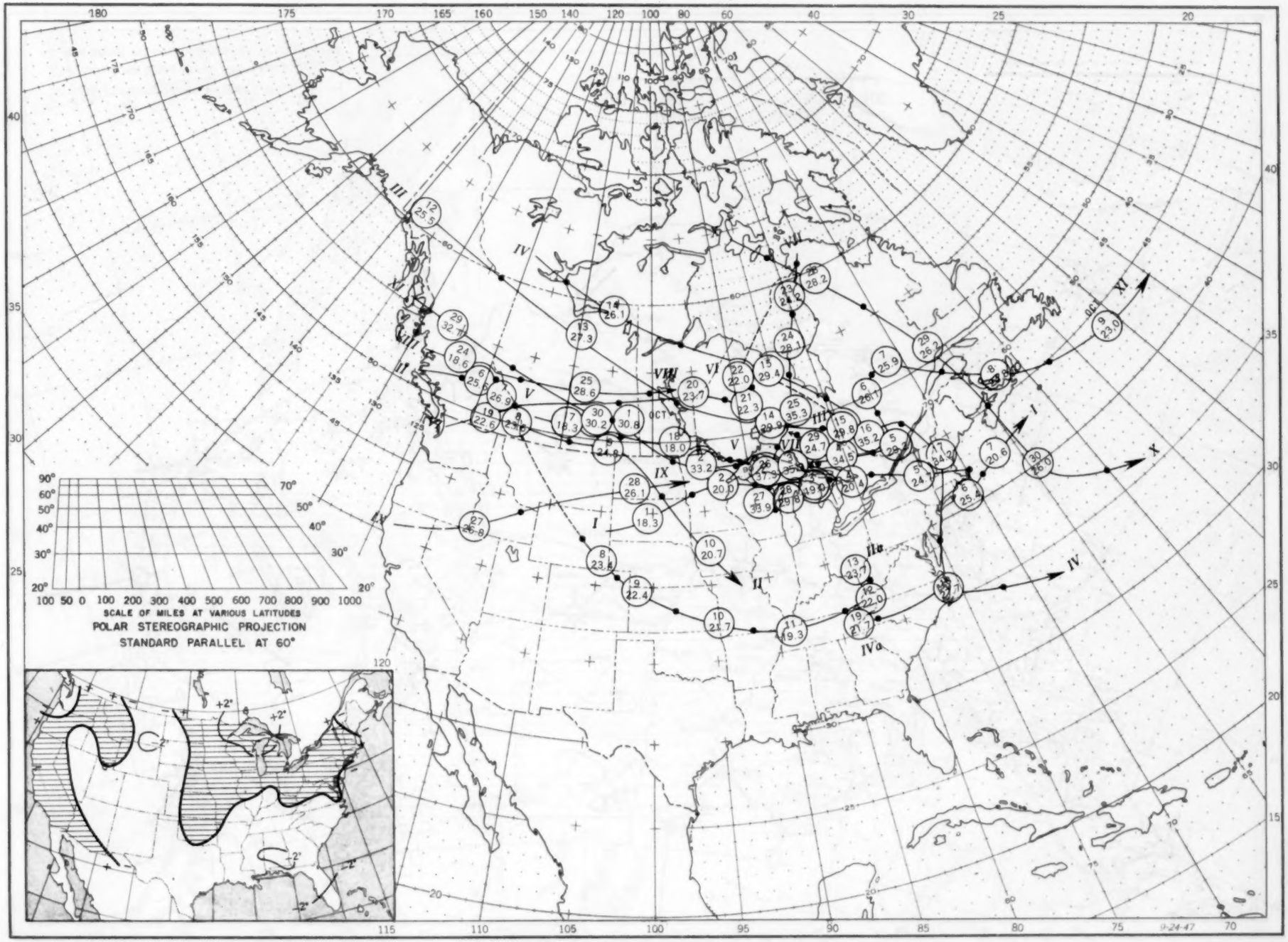

Shaded portions show excess (+)
Unshaded portions show deficiency (−)
Lines show amount of excess or deficiency
HOURLY PERCENTAGES
100 50 50 100
SCALE OF MILES
LAMBERT CONFORMAL PROJECTION. TRUE AT 30° AND 60°

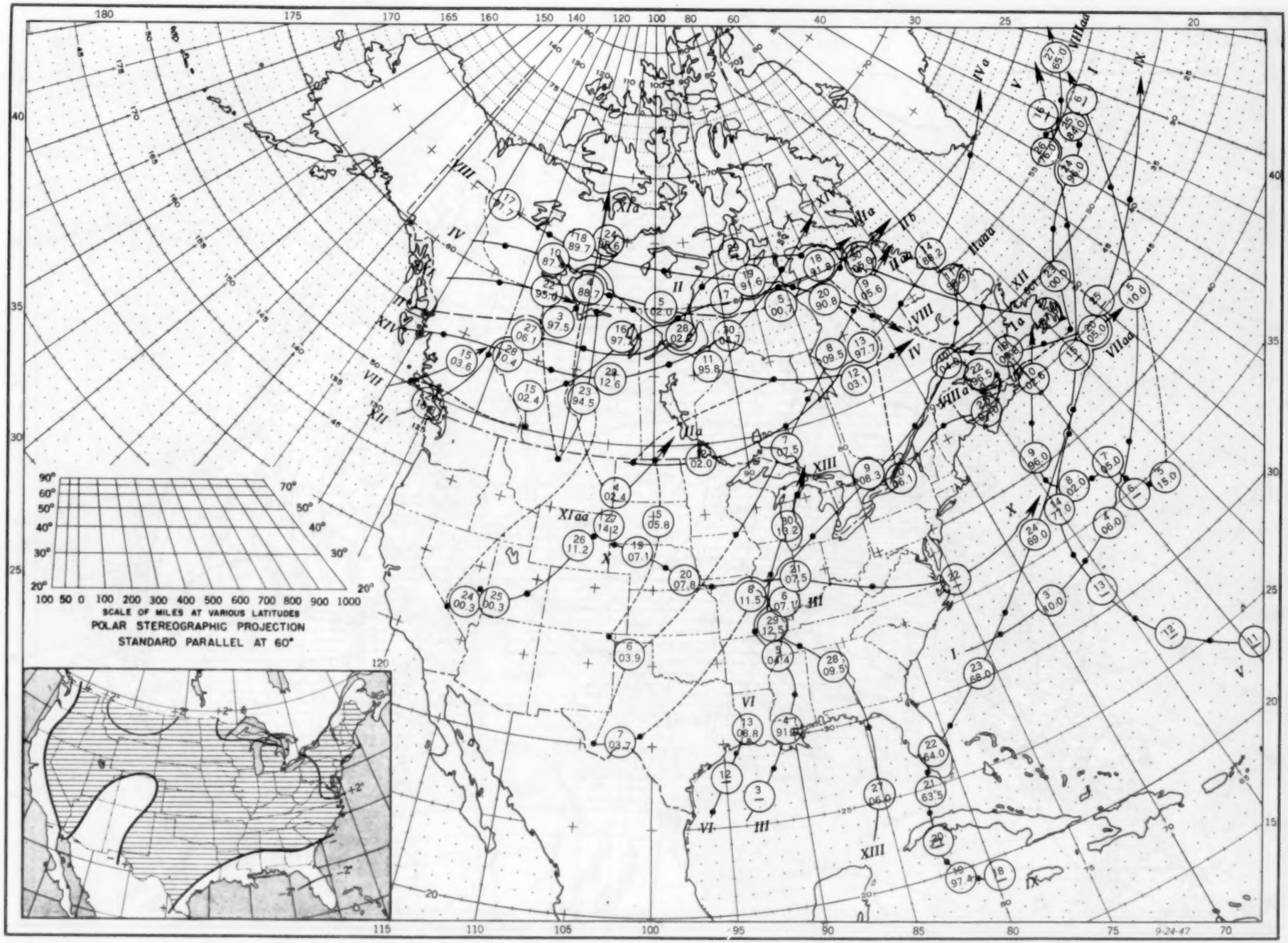
Chart II. Tracks of Centers of Anticyclones, September 1948. (Inset) Departure of Monthly Mean Pressure from Normal



Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time)

Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading.

Chart III. Tracks of Centers of Cyclones, September 1948. (Inset) Change in Mean Pressure from Preceding Month



Circle indicates position of cyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 7:30 p. m. (75th meridian time)

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, September 1948

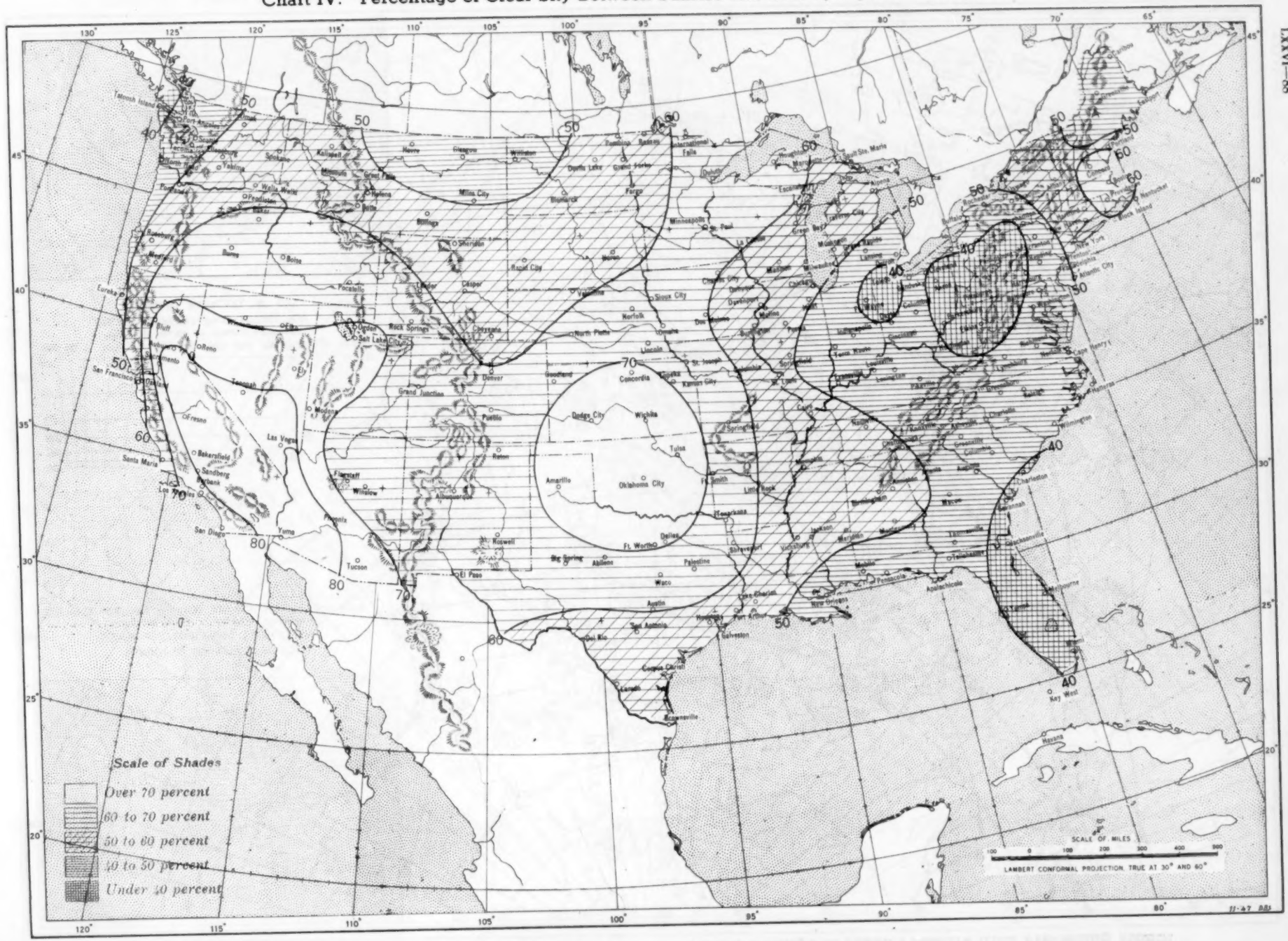


Chart V. Total Precipitation, Inches, September 1948. (Inset) Departure of Precipitation from Normal

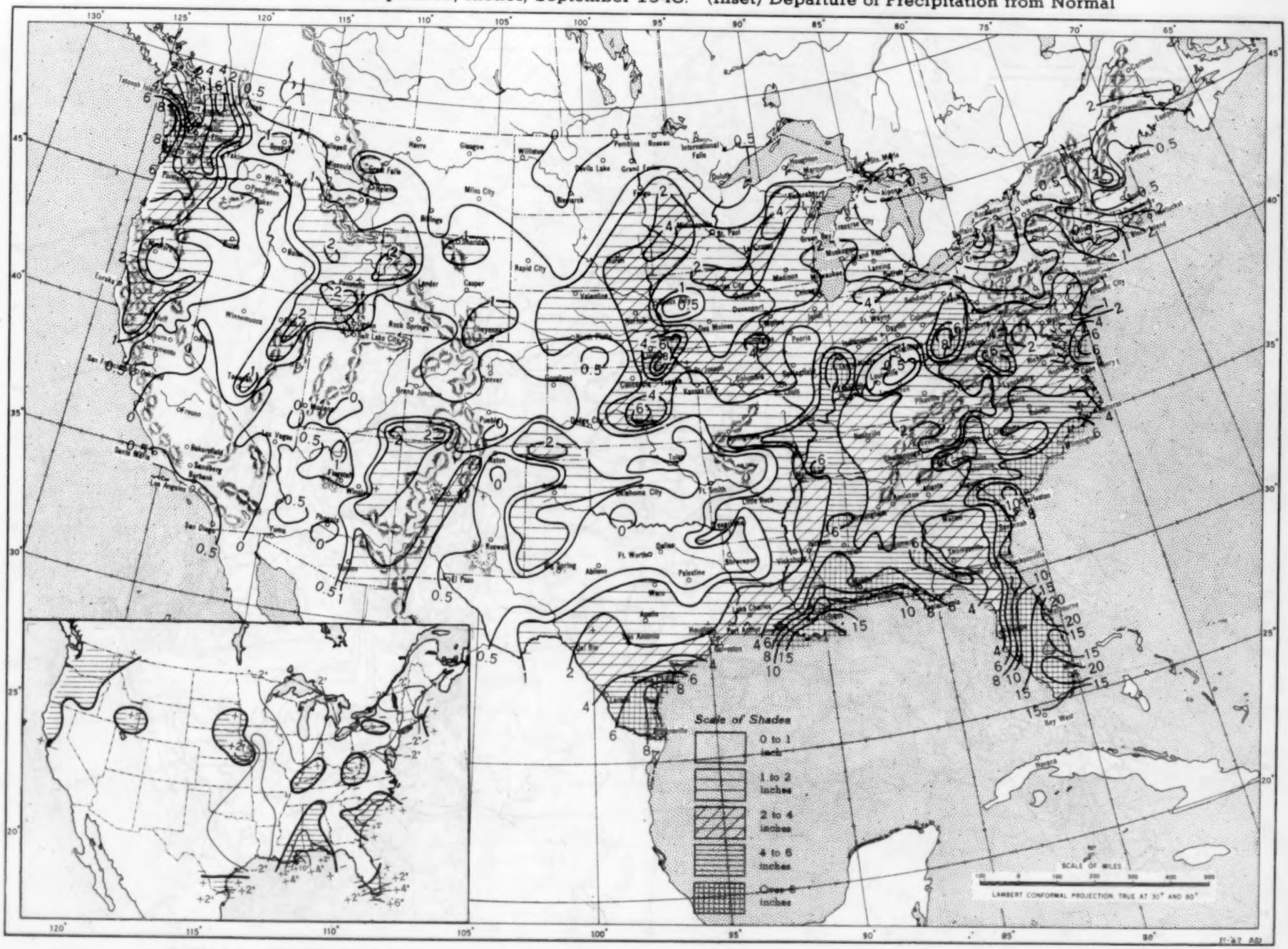

Scale of Shades
0 to 1 inch
1 to 2 inches
2 to 4 inches
4 to 6 inches
Over 6 inches
SCALE OF MILES
LAMBERT CONFORMAL PROJECTION, TRUE AT 30° AND 60°

Chart VI. Isobars (mb.) at Sea Level and Isotherms (°F.) at Surface; Prevailing Winds, September 1948

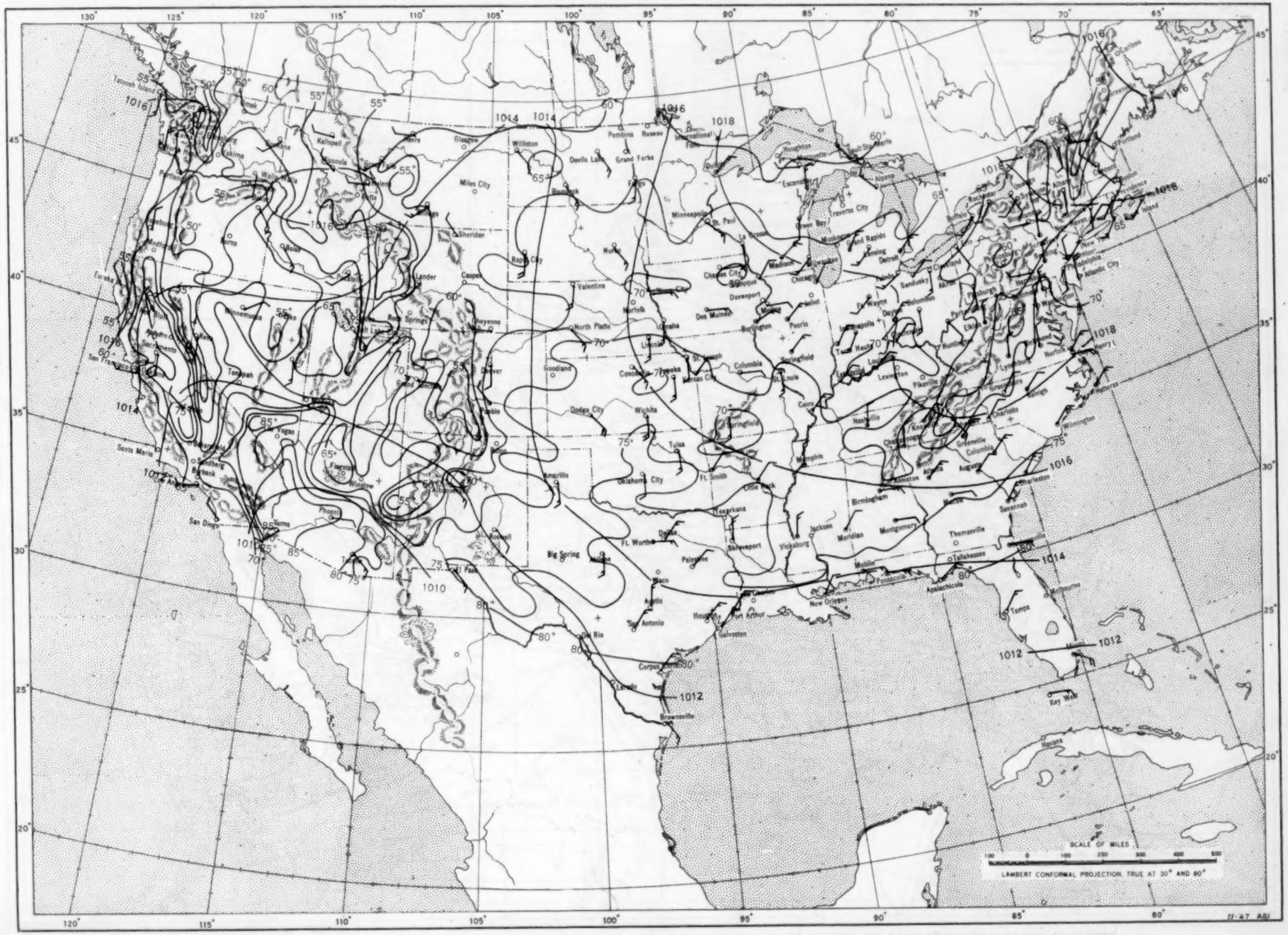
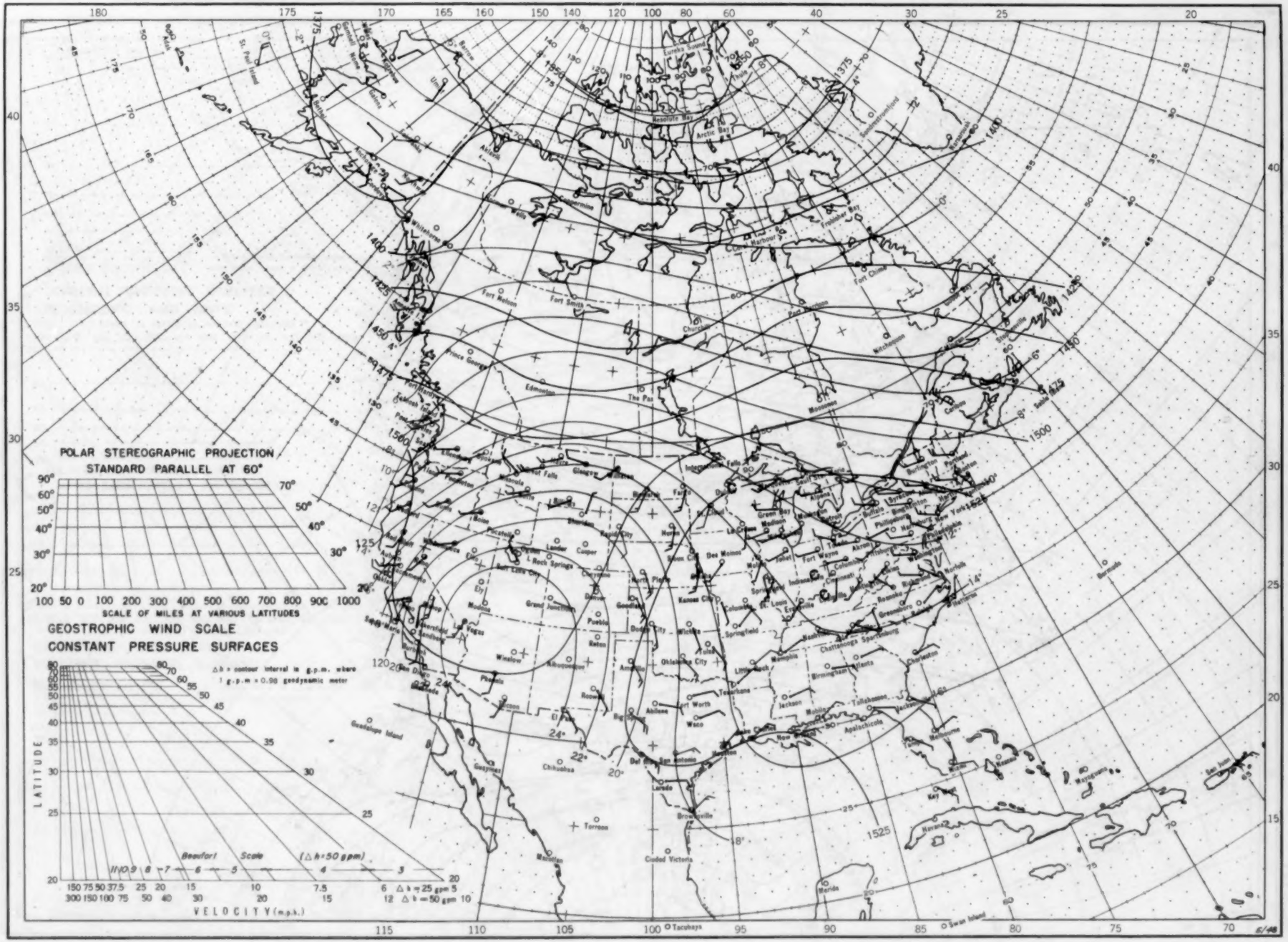


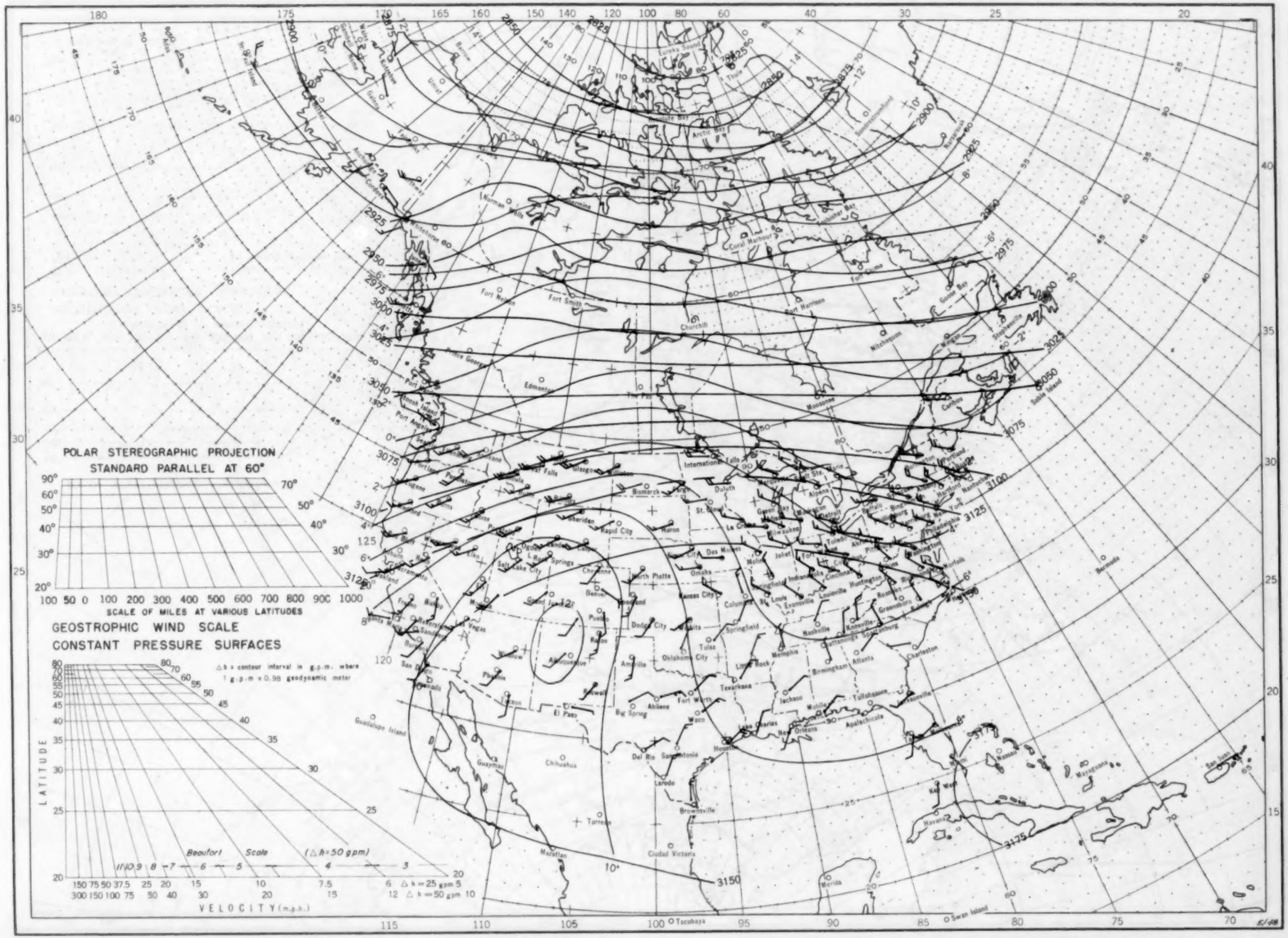
Chart VIII, September 1948. Contour Lines of Dynamic Height (Geopotential) in Units of 0.98 Dynamic Meters and Isotherms in Degrees Centigrade for the 850-millibar Pressure Surface and Prevailing Winds

Chart VIII, September 1948. Contour Lines of Dynamic Height (Geopotential) in Units of 0.98 Dynamic Meters and Isotherms in Degrees Centigrade for the 850-millibar Pressure Surface, and Resultant Winds at 1,500 Meters (m. s. l.)



Contour lines and isotherms based on radiosonde observations at 0300 G. C. T. Winds indicated by black arrows based on pilot balloon observations at 2200 G. C. T.; those indicated by red arrows based on rawins taken at 0300 G. C. T.

Chart IX, September 1948. Contour Lines of Dynamic Height (Geopotential) in Units of 0.98 Dynamic Meters and Isotherms in Degrees Centigrade for the 700-millibar Pressure Surface, and Resultant Winds at 3,000 Meters (m. s. l.)

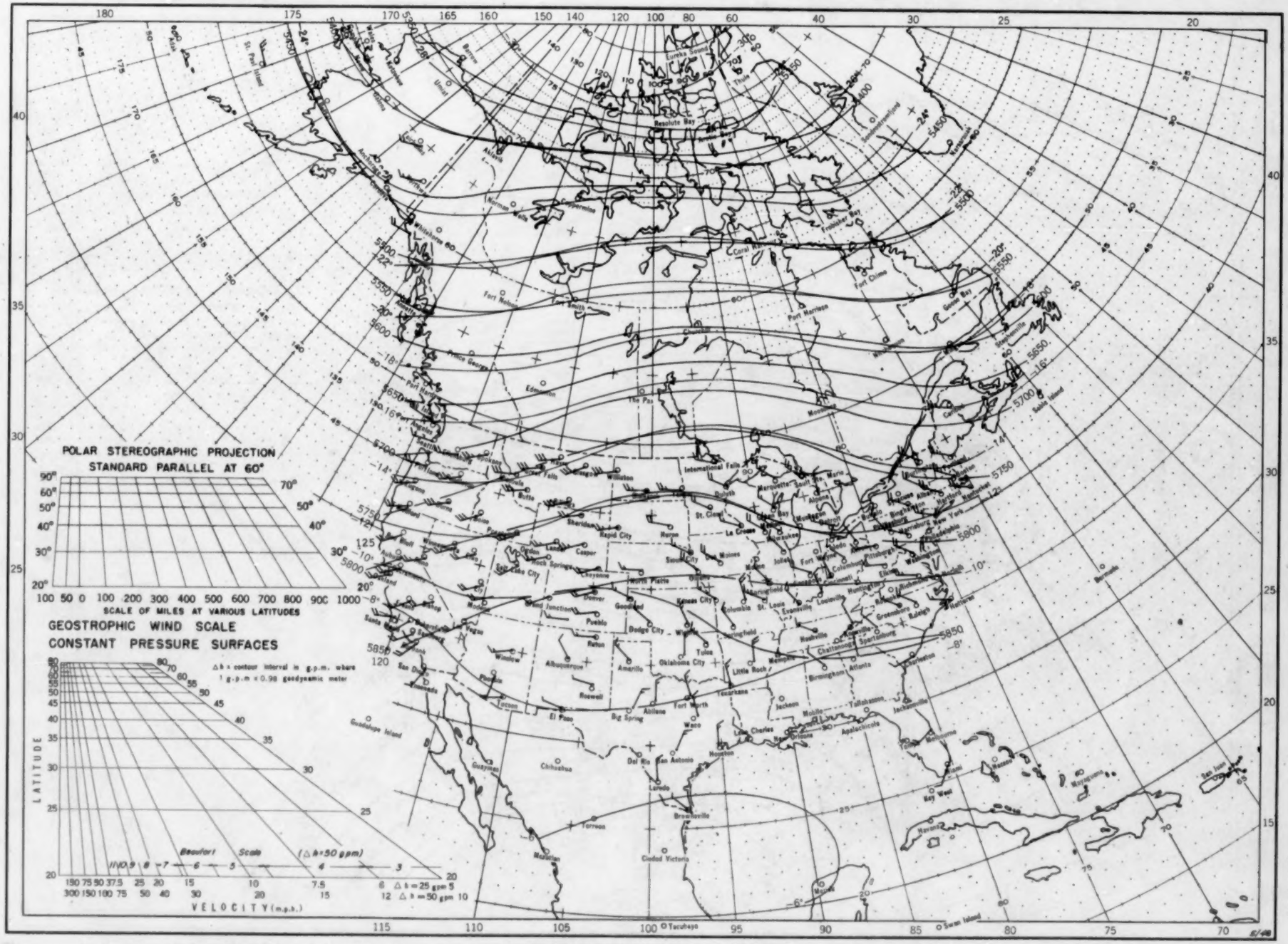


Contour lines and isotherms based on radiosonde observations at 0300 G. C. T. Winds indicated by black arrows based on pilot balloon observations at 2200 G. C. T.; those indicated by red arrows based on rawins taken at 0300 G. C. T.

Chart X, September 1948. Contour Lines of Dynamic Height (Geopotential) in Units of 0.98 Dynamic Meters and Isotherms in

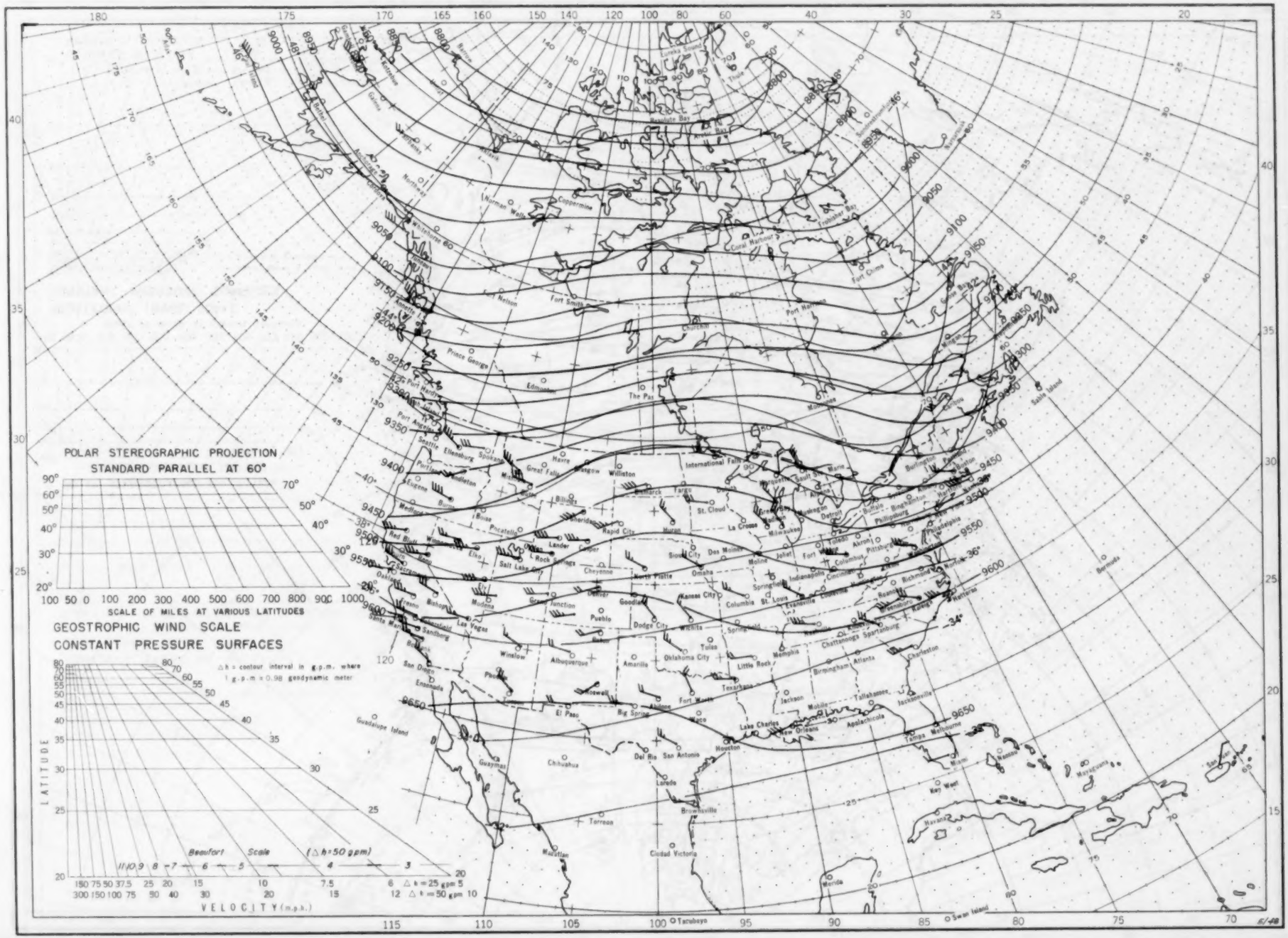
Contour lines and isotherms based on radiosonde observations at 0300 G. C. T. Winds indicated by black arrows based on pilot balloon observations at 2200 G. C. T.;
those indicated by red arrows based on rawins taken at 0300 G. C. T.

Chart X, September 1948. Contour Lines of Dynamic Height (Geopotential) in Units of 0.98 Dynamic Meters and Isotherms in Degrees Centigrade for the 500-millibar Pressure Surface, and Resultant Winds at 5,000 Meters (m. s. l.)



Contour lines and isotherms based on radiosonde observations at 0300 G. C. T. Winds indicated by black arrows based on pilot balloon observations at 2200 G. C. T.; those indicated by red arrows based on rawins taken at 0300 G. C. T.

Chart XI, September 1948. Contour Lines of Dynamic Height (Geopotential) in Units of 0.98 Dynamic Meters and Isotherms in Degrees Centigrade for the 300-millibar Pressure Surface, and Resultant Winds at 10,000 Meters (m. s. l.)



Contour lines and isotherms based on radiosonde observations at 0300 G. C. T. Winds indicated by black arrows based on pilot balloon observations at 2200 G. C. T.; those indicated by red arrows based on rawins taken at 0300 G. C. T.